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Determining the point of optimum transferability of skill

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Determining the Point of Optimum Transferability of Skill

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A report submitted in Partial Fulfilment of the Requirements for the
Award of Bachelor of Arts (Psychology) Honours, Faculty of Computing,
Health and Science

Edith Cowan University

Submitted: 25th October, 2010

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Determining the Point of Optimum Transferability of Skill

Abstract

Cognitive research assumes that practice on a task can lead to improved performance, most often resulting in the attainment of automatic performance and possibly the transfer of this learning to another task. This study examined all of these questions through the use of a computer generated counting task that required participants, consisting of 60 randomly selected university students and friends and family of the researcher, to count stars on a display screen and determine if the number of stars presented was an odd or even number.

Coefficient of variation (CV) measures that calculated the variability for a given level of RT were used to determine when automatic performance was achieved and a *t* test of within subject means examined the data for evidence of transfer. The study found that practice could lead to improved performance, but that this improvement did not always guarantee the attainment of automatic performance. It also showed that in the absence of automatic performance the likelihood of transfer to another task was also decreased. These limitations appeared to be linked to questions of practice, attention, disruption and complexity of the task. Ultimately, the research highlighted the difficulty and inconsistency in achieving skilled or automatic performance, even on seemingly simple tasks, suggesting that the attainment of automatic performance and accordingly, transfers may be more susceptible to peripheral influences than had been originally considered. The implications of these finding will be in its influence on how future skill acquisition research may be structured, in relation to the type of task used and the length and type of practice that may be required, with possibly greater consideration also being given to the role of secondary influences on the attainment of automaticity and transfer.

Amanda Puchar

Supervisor: Professor Craig Speelman

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Determining the Point of Optimum Transferability of Skill

Two important functions of skill acquisition research have been to determine how an individual can improve performance on learned skills and how this improved performance can then assist an individual to perform on another task. Research has examined many areas influencing the acquisition and transfer of skills including the impact of practice on skilled performance, the importance of attention on learning a new skill, the relevance of controlled and automatic processing, how automatic performance can be measured, the circumstances from which transfer of skill is most likely to occur and the influences that can affect transfer. This research will further develop these questions, with the aim of determining whether practice will, in time, lead to automatic performance, whether the coefficient of variation can determine the point where automaticity has been achieved, whether reaching this point of automaticity can be a catalyst for skill transfer to another task or whether unique influences will interfere with the ability to achieve this transfer.

An overview of automaticity research

The acquisition of skills by an individual is generally discussed in cognitive psychology as occurring in three stages (Bebko, Demark, Osborn, Majumber, Ricciuti & Rhee, 2003). Ackerman's theory of these stages was developed from the combination of three skill acquisition theories. Fitts' (1964) theory of skill acquisition, the integration of Shiffrin and Schneider's (1977) theory of controlled and automatic processing, and Ackerman's own (1992) theory of change in skill acquisition as a function of task characteristics. The three stages are known as the cognitive, associative and autonomous stages of skill acquisition (Bebko et al, 2003).

According to Ackerman (1992), the first stage, the cognitive stage, is where controlled processing is utilised and early learning places heavy demands on the learner as they attempt to understand instruction and develop strategies. The next stage is the associative stage and involves the composition (collapsing of several procedures) and proceduralisation of task strategies in a way that will enhance performance and reduce errors (Ackerman, 1992). In the final stage, the autonomous stage, the learner can complete a task with little attentional effort and so performance is said to be automatic (Ackerman, 1992).

Charness and Campbell (1988) refer to the stages of composition and proceduralisation as the compilation stage. Composition is seen as the collapsing of several procedures into a single production (i.e., condition-action pairs or if-then statements). These productions must occur in sequence and share the same overall goal. These new productions then do

the work of the sequence, but in fewer steps (Anderson, 1987). Proceduralisation eliminates reference to declarative facts by developing domain-specific productions that remove the need for declarative information to be held in working memory (Anderson, 1987). The advantage of compiling knowledge is that when conditions in the environment match a production or procedural knowledge set (Anderson, 1987) the production can be executed immediately, in contrast to the slower bringing of knowledge into working memory and applying productions to it (Charness & Campbell, 1988).

How automatic performance is measured

The measure of automatic performance (i.e., tasks performed in parallel and without attention) has been determined by a statistical measure called the coefficient of variation (CV) or the standard deviation of RT divided by the mean reaction time ($SD_{RT} / \text{mean RT}$). The rationale for using the CV rather than the mean RT is that the CV assesses duration variability rather than simply duration itself. As such, the CV “can be used to compare individual and group performance independent of mean RT differences, as well as performance across tasks that make different response time demands” (Hulstijn et al., 2009, p. 578). This difference can also be considered a proportional or disproportional reduction of variability or where a CV reduction reflects a decrease in variability relative to the mean RT, hence, an increase in performance stability (Segalowitz & Segalowitz, 1993).

The CV measure also enables the differentiation between change in response times that are quantitative in nature and changes that are qualitative. Quantitative changes are seen as being the result of speed-up effects only, which result from facilitatory effects, or where there is an across the board strengthening or acceleration in the processes involved in the task. This is signified by any change in the *SD* being linearly proportional to changes in the overall RT. (Segalowitz & Segalowitz, 1993). In contrast, qualitative change is believed to result from speed-up and restructuring effects, whereby instead of simply speeding up the operations of the component processes, practice may enable underlying processes to become utilised differently (i.e., inefficient processes are replaced by more efficient processes), resulting in the *SD* being reduced over and above what would be expected by dint of the RT (Segalowitz & Segalowitz, 1993).

However, concerns have been raised as to the legitimacy of the CV as a true measure of automaticity. Hulstijn et al. (2009) noted that disproportional or qualitative change in processing RT/ variability correlations, an assumed indicator of automatisisation, can also be as a result of speed up of performance, suggesting that the CV may not only be an indicator

of automatic performance, but could also indicate a speeding up of component processes as a result of increased practice. This then limits the internal validity of all automaticity research that relies on the CV as its core measure.

Controlled and automatic processing and the role of practice and attention

In skill acquisition research a distinction is often made between the controlled and automatic operations that underlie cognitive tasks, with the most complex cognitive tasks involving the use of processes that require the use of cognitive effort (Segalowitz & Segalowitz, 1993). These processes include strategic control and attention and are consequently vulnerable to interference (Segalowitz & Segalowitz, 1993); interference in this instance referring to powerful environmental stimuli and habitual responses (Kane, Bleckley, Conway & Engle, 2001).

Under certain conditions, practice has been found to lead to faster, less effortful and stable performance or what is otherwise known as automatised performance or automaticity (Segalowitz & Segalowitz, 1993). Automaticity, the outcome or final product of skill acquisition, enables individuals to progress from slow, conscious, controlled processing of factual and rule based knowledge, to a rapid, attention-free processing consisting largely of routines characterised by "chunks" of elementary operations (Hulstijn, Van Gelderen & Schoonen, 2009). This is believed to occur because, while controlled processing is seen to involve mechanisms that result in relatively slow and variable execution times, practice reduces or eliminates their influence, consequently speeding-up and stabilising performance (Segalowitz & Segalowitz, 1993). Rickard (1997) describes the process of progressing from controlled to automatic processing as a strategy shift whereby skill acquisition is achieved by a move from generic, multistep procedures to direct retrieval of answers from memory. Siegler (1988) noted, through research using single-digit arithmetic equations, that during the initial stages of learning, children often used counting procedures that required 10 seconds or longer to execute. With sufficient practice, the children were then able to retrieve answers to individual problems directly from memory and by adulthood, this direct retrieval method was able to yield answers in about 1 second. Therefore, practice and attention are believed to aid in the transition from the use of primarily controlled processes towards the greater use of automatic processes.

While skill acquisition research supports the generalisation that practice leads to skilled performance, Spelman and Kirsner (1997) note that on occasions, practice may not lead to skilled performance. Research carried out by Bebeko et al. (2003) appears to support this

claim. Bebko et al. conducted an experiment that tested the level of skill automaticity in 10 jugglers of various levels of competency, and found that despite extensive practice many intermediate skill level jugglers and all low skill level jugglers (one participant) never reached the level of automaticity (i.e., skilled performance), despite five weeks of juggling practice. Ten graduate students and their spouses or relatives (5 men and 5 women) between the ages of 23-32 years, all of whom had no previous three-ball juggling experience, were all given a standardised training session of 25 minutes in the art of three-ball juggling, before assessments were made as to each participants' relative initial skill level. Regular practice of 15 minutes a day, five days a week for 5 weeks was then completed by all participants. The level of automaticity was then determined by a professional juggler to be 20 catches per trial and all participants were then graded into one of three groups; proficient, emerging and late learner. Only the proficient group had reached the level of automaticity (Bebko et al., 2003).

Results from the study indicated that members of the proficient group acquired and automatised the juggling task quickly and maintained their superior performance throughout the duration of the study. The emerging group took longer to acquire the juggling skill but did not fully automatise their performance, while the late learner took a substantially longer time to learn the skill and was never close to automatising their performance. These findings appear to support the belief that automatised performance is not always achieved, despite practicing a skill over a long period (Bebko et al., 2003).

While the time limit of five weeks practice on the juggling task limits the comprehensiveness of the research results, it does suggest that for some individuals, automatic performance may not always be achievable in what may be subjectively considered a "practical time frame" if it is achievable at all. This must also be tempered by the fact that three-ball juggling is considered to be a complex task and that given extra time all participants may have attained an automatised skill level. In that case, the only variation between individuals' attainment of automatised performance, would be the individual differences of innate abilities in the particular task (e.g., sporting ability, hand-eye co-ordination). Research that involves tasks that could be reasonably expected to be mastered in a shorter time span may be required to resolve this uncertainty.

Therefore, while research suggests that individuals can be expected to reach automatic performance with sufficient practice, research also suggests that depending on the level of

complexity of the task and specific individual abilities to perform the particular task, reaching such a level of performance may not be guaranteed.

Automaticity or restructuring?

Cheng (1985) questions whether a dichotomy between automatic and controlled processing is the only explanation for improved task performance. Cheng noted that according to Shiffrin and Schneider (1977) controlled processing was essentially categorised as being capacity demanding (i.e., load dependent) whereas automatic processing was not. Shiffrin and Schneider believed that when a component of a task becomes capacity free, an individuals' attention can be devoted to other components of the task. As enough components become capacity free, a once difficult or seemingly impossible task becomes easy or possible. Cheng reasoned that improvements in performance could just as easily be explained by a restructuring of task components. This could be achieved by the task components being coordinated, integrated and reorganised into new perceptual, cognitive or motor units, thus allowing the procedure involving the old components to be replaced by a more efficient procedure involving new components.

Cheng (1985) argued that the two procedures used to calculate the sum of ten 2's can be calculated through the use of nine addition operations or the multiplication of 2×10 via memory retrieval. This gain in efficiency, Cheng believes, is not as a result of performing the nine addition operations in a capacity-free manner, as those operations are not performed at all. Neither is the gain in efficiency as a result of performing an automatic multiplication operation. Cheng believes overcoming limitations in performance are not necessarily achieved by shifting from capacity-demanding into a capacity-free mode of processing, but may also be achieved through a restructuring of the task procedures. In other words, Cheng differentiates automatised performance (i.e., capacity free processing) from restructuring of task components, although conceding that the two processes are not mutually exclusive, and that processes can conceivably be both restructured and automatised (Cheng, 1985). Segalowitz and Segalowitz (1993) and Spelman and Kirsner (1997) also recognise Cheng's (1985) theory of restructuring of component processes, and view restructuring as an important procedure that leads to automatic processing operations.

Support for automaticity as measured by the CV

While reviewing established skill acquisition research data, Segalowitz and Segalowitz (1993) noted that bilinguals who read more quickly in their first language (L1)

(presumably because they had had more practice) than in their second language (L2), exhibited both longer lexical decision response times (RT) and greater RT variability in L2 than L1, suggesting that the faster the readers were able to recognise an item as a word, the more stable their RT was.

Segalowitz and Segalowitz (1993) explained this difference as being the result of both quantitative and qualitative changes in task component processes. Quantitative changes are seen as being the result of speed-up effects only, whereas qualitative change is believed to result from a restructuring effect (Cheng, 1985; Segalowitz & Segalowitz, 1993) where practice may enable underlying processes to become organised differently (Segalowitz & Segalowitz, 1993).

To further test their theory, Segalowitz and Segalowitz (1993) conducted two experiments which examined both quantitative and qualitative changes in the skill acquisition processes. The first experiment, involved the use of 66 French speaking students, between the ages of 18 to 25 years, who were enrolled in a summer program in English as a second language (ESL). The experiment investigated the relationship between RT, *SD* and CV for a simple task in which individual differences were not expected to involve differential use of effortful processes. The CV measure was selected with the aim of assessing duration variability rather than duration alone (Hulstijn et al., 2009). This simple task involved a RT task that required the detection of the onset of a visual stimulus (Segalowitz & Segalowitz, 1993).

The results of the experiment were that *SD* correlated significantly with RT while CV did not, supporting Segalowitz and Segalowitz's (1993) theoretical position that individual differences in *SD* for a simple detection task do not necessarily reflect changes to the organisation of the processes underlying the task, but rather simply involve speed-up of performance. This was presumed to be a reflection of an increased speed of responding, as opposed to a reorganisation of the component processes underlying the task.

The second experiment that involved the use of the same 66 participants, in the ESL program, investigated the relationship between RT, *SD* and CV for a task in which individual differences were more likely to involve differential use of effortful processes. The participants were rated in English fluency from beginner to near fluent and were then required to perform a lexical decision task with 284 English words and nonwords. The lexical decision task required the participants to determine which letter strings were English words and which were not.

The results showed that the *SD* correlated significantly with RT and the CV also correlated significantly with the RT. Thus, faster participants showed less variability than slower subjects, suggesting a difference that was more than the proportional reduction that could be expected from simply faster processing (i.e., qualitative change). These results were consistent with Segalowitz and Segalowitz's (1993) belief that for complex tasks, faster participants used fewer effortful processes that were slower acting or highly variable. Or in other words, faster participants used less controlled processes than did slower participants.

Further analysis of RT data which explored the relationship between RT, *SD* and CV between two groups of 22 participants who were categorised as being in either the extreme slow end or the fastest end of RTs for word recognition skills, found that mean reaction times for the slowest performers was 1203 msec, with a CV/mean RT correlation of .20 (n.s), while for the fastest readers the mean RT was 745 msec and CV/mean RT of $r = .55$ ($p < .001$). These results suggest that the slower group were more likely to differ from each other primarily in the speed with which many underlying components of word recognition were executed and less by the extent to which effortful processes were utilised. In contrast, the faster group showed a differential reliance on underlying effortful processes and that gains in word recognition skills (faster responding) were associated with large decreases in variability of responding (Segalowitz & Segalowitz, 1993).

Hulstijn et al. (2009) tested Segalowitz and Segalowitz's (1993) conclusions by examining studies conducted by Van Gelderen, Schoonen, Stoel, De Glopper and Hulstijn (2007) on receptor and production skills and Fukkink, Hulstijn and Simis (2005) on visual lexical decision skills. Van Gelderen et al.'s (2007) non-experimental longitudinal study examined RTs on four tasks including a lexical decision task, a lexical retrieval task, a sentence verification task and a sentence production task. Each battery of 21 tests was conducted three times, when students were in grades 8, 9 and 10. Of the 397 students that participated in the research twenty-nine percent were considered to be bilingual. The label language one (L1) was assigned to Dutch and language two (L2) to English.

Results of the study were that students became faster over time (years 1, 2 and 3) in all four language tasks, as reflected by the decrease in the mean RT and mean standard deviation for each task over the three year period (i.e., practice improved RTs). However, the expected decrease in CV was found in only two of the lexical decision tasks and in none of the tasks that required sentence construction and sentence verification, suggesting

the results obtained by Segalowitz and Segalowitz may be task specific (i.e., may only apply to lexical decision tasks on ESL participants). Furthermore, the fact that 29 of the participants in this study were considered to be bilingual also affects the ability to clearly differentiate between L1 and L2 students, an important distinction for the internal validity of the research.

Longitudinal research conducted by Fukkink et al. (2005) also measured the RTs of participants who performed a visual lexical decision task, before and after training, that was aimed at speeding up the mapping of word forms with their meanings. The participants were 41 students from two Grade 8 school groups (ages 13-14 years). The students had received English instruction for an average of 3.5 years. The English words selected for the lexical decision task were commonly used English words to maximise the likelihood that the students would be familiar with the lexical material. One hundred word stimuli and 90 pseudoword stimuli were used pre-test and post-test and offered in random order.

In the first analysis of the data, the results found that participants performed more accurately after training than before training. A significant decrease in mean RTs was also found as was an increase in the RT-CV correlation. However, significant decreases in CV values, which may be suggestive of automatisation, were not found.

A second analysis of the data compared pre and posttest performance on words already known in the pretest. This analysis was used to investigate whether knowledge already present at one point of time, becomes more automatic at a later point of time. The CV values following this analysis also did not decrease significantly.

On a third analysis, outliers were removed from the data and again no significant drop in CV was found. On a fourth analysis data containing more than two incorrect answers, in both pre and posttest data were removed along with outliers. In this case, a significant decrease in CV was found. The final analysis which returned to raw scores and removed all data from students with more than two incorrect answers also found a significant decrease in CV.

These results suggest that the evidence of automatisation as defined by Segalowitz and Segalowitz (1993) was only found in visual lexical decision data that had removed participants that had made more than two errors in the task. All other data showed no support for automatisation of skill over time.

One limitation of comparing the lexical decision task data conducted by Segalowitz and Segalowitz (1993) and Fukkink et al. (2005) is the length of time of the studies. Fukkink et al. conducted a longitudinal study while Segalowitz and Segalowitz did not. This does not consider the possibility that different processes may be involved in skills acquired over different time periods. This hypothesis receives qualified support from the comparison of research conducted by Carlson, Sullivan and Schneider (1989) utilising judgments about logic gates and research by Frensch (1991) utilising the Elio task (see Figure 1. Shown page 17). Despite 8,000 trials, results from the judgment task showed no composition effects, while the Elio task showed composition effects after only 75 practice trials. One of the major differences between the two tasks is that the judgment task was processed much more quickly than the Elio task, suggesting that very rapidly executed sequences of steps may be inaccessible to automatic mechanisms of composition. It is also possible that tasks processed over long periods may utilise different processes than tasks processed over a shorter time frame and as such, the research data attained from these different studies may not be directly comparable.

Harrington (2006) also conducted a research study which utilised a visual lexical decision task with ESL participants. The lexical decision task used four frequency bands of English words. Thirty-two students were intermediate level ESL students, 36 advanced ESL students and 42 native speakers of English. The results showed that the intermediate ESL group was consistently less accurate and slower than the advanced group, who in turn, were less accurate and slower than the native English speakers. CV and RT correlations for intermediate students only reached significance in the most frequent word class. For the advanced students CV-RT correlations were significant for all but the lowest frequency word class. In the case of native speakers, CV-RT correlations were significant in all four frequency word classes (Harrington, 2006).

These results appear to support Segalowitz and Segalowitz's (1993) theory of automaticity in skilled performance, as across the board CV-RT correlations, suggestive of automaticity, were found in only highly skilled participants, and were less frequent as the level of proficiency of the participants decreased. However, any possible CV reduction was not reported in the research. Once again, this limited support of Segalowitz and Segalowitz's theory, could only be obtained when a visual lexical decision task with ESL participants was used.

Overall, support for automaticity as determined by the CV measure could be considered highly conditional. Lexical decision tasks appeared to show the predicted RT/CV correlations but did not always show a decrease in CV, as was also predicted. When RT/CV correlations were found, often it was only after data cleaning had occurred. Lexical decision tasks regularly indicated automaticity, while others tasks did not. Research designs were often similar in task structure, but different in task duration or study length, making direct comparisons difficult. This suggests that while some support for the CV measure for the detection of automatic performance was found, it may be selectively affirming. And while research appears to suggest that automatic performance will most likely occur in individuals who have received the most amount of practice, the inconsistency of these research findings also suggests that results obtained may be restricted in their generalisability to the particular task used in each experiment.

Is there a point of automaticity?

The acquisition of skills is generally accepted as requiring considerable time and requiring much practice (Hulstijn et al. 2009). In fact, Anderson (1982) suggests that it takes at least 100 hours of learning and practice to acquire a high degree of proficiency in any significant cognitive skill. This high degree of skill proficiency is believed to be as a result of practice on a particular skill resulting in faster, less effortful and stable performance or what is termed the point of automaticity.

However, the use of the term “point of automaticity” is problematic, as it implies that automaticity can be determined on one point on the continuum between controlled and automatic processing. Segalowitz and Segalowitz (1993) believe that complex tasks require a melding of automatic and controlled processes and that automaticity occurs when less controlled processes are required to perform a specific task. Therefore, a clear delineation between controlled and automatic processing, as is implied by the term “point of automaticity” may be considered inappropriate. Automaticity is possibly best described as an “area” in which automatic performance can be observed, or a zone where the gradual reduction in the variability between RT and *SD* can be detected. A reduction implies that a set of consecutive data must be examined before a decrease in variability can be ascertained, thus a “point” of automaticity appears to be an inaccurate representation. Moreover, Hulstijn et al. (2009) also determined that a RT-CV correlation, also believed to be suggestive of automatised performance, is often found at times when decreases in CV are not.

This suggestion of an “area of automaticity” may be supported by research by Bebkö et al. (2003). The three-ball juggling experiment determined that automaticity could be assumed for an individual participant who was able to juggle the three balls non-stop for 20 throws (i.e., the point of automaticity was determined to be 20 consecutive throws). This was an arbitrary subjective figure that was selected by a professional juggler. The difficulty with this arbitrary figure being used to establish automaticity is, on what basis did the professional juggler choose 20 throws as the point of automaticity rather than, for instance, 21 throws? Also, what conclusions should then be made about those participants who juggled the balls 19 times rather than 20 times? Does this suggest that the difference between automaticity and non-automaticity can be determined by one throw?

These observations imply that any attempt to make assumptions that automaticity can be found on one point of the scale between controlled and automatic processing should be made with caution. Consideration should also be given to the possibility that the detection of automaticity may be less precisely defined than first thought and that it may be an examination of the trend in the data that may give the greatest insight into when automatic performance has been achieved.

Transfer of acquired skill

An important issue in skill acquisition research is transfer, where research has focused on the factors that affect how training in one situation will improve performance in another situation (Speelman & Kirsner, 2005). Skill acquisition research has been faced with two major and essentially opposing theories that attempt to explain the concept of transfer. Logan’s Instance theory (1988) and Anderson’s ACT theory (1992). Logan proposed that attention functions to assemble individual task components into novel arrangements. When the same sequence of task components is repeatedly executed the task components become interassociated, thereby reducing the need for attention to combine them (Frensch, 1991). Logan’s theory assumes that practice increases the associative strength between separately stored memory representations (Frensch, 1991). Therefore, skill is developed through an accumulation of experiences a person acquires through practice or exposure to a certain task. Retrieval of these experiences to enable future performance is seen as being very task specific. According to this theory, transfer to new related tasks will not occur (Speelman & Kirsner, 1997).

Anderson’s theory suggests that with practice, existing memory representations are collapsed into new and larger memory representations and that a “composition”

mechanism automatically combines serially executed individual productions into a smaller number of highly specific new productions. In turn, composition then leads to increased speed of execution because fewer production rules (i.e., rules that determine that under certain conditions, particular actions will be performed) need to be executed. The composition mechanism is believed to be constrained by a number of factors, including goal-relatedness of the to-be-composed productions and the capacity of working memory (Frensch, 1991). Consequently, Anderson, who views skill acquisition in more abstract terms, believes that the degree to which skills acquired with a particular task can be transferred to the performance of another task relates to the degree to which the procedures learned in the first task overlap with those required to perform the new task. The more these procedures overlap, the greater the transfer (Speelman & Kirsner, 1997).

A more recent theory that has examined skill transfer is Speelman and Kirsner's (2005) component theory of skill acquisition. This theory views the human brain/mind as a complex system, whose component processors or agents receive, process and transmit information. The survival of these agents is only assured by their on-going utility or usefulness in processing a particular task or closely aligned task (Speelman & Kirsner, 2005). Some agents will develop that are specific to a task, while others are able to be recruited to perform in many tasks, depending on the nature and context of the particular task, thereby allowing for partial transfer between tasks (Speelman & Kirsner, 2005). Partial transfer is viewed as a level of transfer between complete and zero transfer. Complete transfer to a new task appears very much as a continuation of previous performance, whereas zero transfer shows itself as performance that is at beginner level. Complete transfer would be exhibited by performance times at least as fast as the last performance of the old related task, whereas zero transfer would be evident by performance times that were at least as slow as the initial performance on the old task (Speelman & Kirsner, 1997).

While this research is strongly suggestive that some transfer is possible for related tasks, Speelman and Kirsner (2005) maintain that it is still preferable to practice for the specific task itself, rather than an approximation of the task.

Healy, Wohldmann, Sutton and Bourne (2006) who investigated specificity of transfer via response inhibition of normal responses, concluded, as proposed by the "procedural reinstatement principle", that an individual will show long-term retention and transfer of performance during skill testing only when the mental procedures developed during

training can be duplicated at the time of test. This suggests that it is not sufficient to have identical elements or even identical component procedures, but it may be necessary that the total configurations of procedures be identical at training and testing (Healy et al., 2006).

Overall, skill acquisition and transfer research suggests that transfer of skill is possible between two related tasks, but that this transfer is limited. The level of transfer relies on factors including the similarity of components underlying the two tasks, the utility of the skill to be transferred and may also require that the mental productions experienced during training, be duplicated during test.

The overall implication of this research appears to be that for complete transfer to another task to occur, direct retrieval from memory would be required (i.e., the use of recognition) or for partial transfer to another similar and related task to occur, the amount of transfer would be highly dependent on the amount and type of training a person received.

Extraneous factors that influence the degree of transfer

Transfer of skill can also be influenced by other factors including context, the variability of the task practice, whether physical or mental practice was used, and the age of the participants participating in the task. Context effects demonstrate how skilled performance can be disrupted by a change in task conditions. Transfer experiments conducted by Speelman and Kirsner (2005) revealed that performance on old skills in new tasks disrupted the performance of the old skills (i.e., old skills were performed slower during transfer than was predicted by extrapolating the training learning curve). Generally, this disruption is only temporary with further practice on transfer tasks returning transfer to levels predicted by training learning curves (Speelman & Kirsner, 2005).

However, transfer research conducted by Forbes (2000) and Giesen (2000) also found that this return to predicted learning curve levels did not occur if the change in context was so dramatic as to necessitate the re-evaluation of the task requirements. This suggests that transfer may not be an automatic function of having the appropriate skills to apply to certain situations and that the extent of transfer is more complicated than simply bringing together the requisite skill components (Speelman & Kirsner, 2005).

One example of context effects is contextual interference, where training type can influence skill type and transfer. It suggests that people are sensitive to regularities in a task environment and the skills they develop to perform the task are a reflection of their

adaptation to these regularities. If the transfer task does not possess the same regularities as was encountered during training, restrictions of transfer to different versions of the task will occur. The disruption to skilled performance created by a change in task conditions is believed to occur because people are adapting to a new situation, and this affects all performance (Speelman & Kirsner, 2005).

Variability, as applied to skill acquisition, is understood as the number of different ways in which something is done. Research by Stokes, Lai, Holtz, Rigsbee and Cherrick (2008) that investigated the effects of practice variability on transfer, discovered that variability appeared to facilitate transfer to novel tasks, in those who had been taught to become sensitive to changes in contingency. This is believed to occur because (a) early practice that requires high variability sensitises learners to changes in condition and (b) such perception-performance links facilitate transfer by activating appropriate alternative strategies/ schema or construction of variants thereof. Stokes et al. explains the mechanism by which such sensitivities are acquired as operant conditioning, where all aspects of responding that are associated with success, increase in frequency.

Age-related differences in the effects of practice on cognitive performance are often attributed to deficits in the speed of efficiency of the control processes involved in learning. These deficits are believed to be demonstrated by the fact that older adults learn new associative links less readily than younger adults do. The influence of age on the degree of transfer was investigated by Touron, Hoyer and Cerella (2001). With the use of 24 young adults, between the ages of 18 and 21 years and 24 older adult community-residing participants between the age of 64 and 75 years, Touron et al. conducted an experiment where participants were given extensive practice with two sets of problem instances, through the use of the Visual Basics computer program. The participants were then asked to complete true or false selections on 600 experimental trials of alphabet arithmetic equations. (i.e., $3 + A = 4$) Reaction times were then calculated for each participant. Baseline tests for memory, perceptual speed and numerical speed were taken before the experimental task began. The results found a relatively large improvement in learning rate for young adults in Set 2, indicating a pronounced benefit from computational (i.e., control processes) practice on subsequent learning for younger adults than for older adults. These results suggest that the transfer of algorithmic learning and the benefit of Set 1 practice was greater for younger adults than older adults. A limitation of this research is that no effort was made to equalise the two groups for extent of contemporary learning or utilisation of cognitive processes. It could be expected that individuals who are in the

process of employing cognitive processes for learning of challenging new skills, as would apply to existing university students, may have a learning advantage over those who were not engage in such learning.

Dahlin, Nyberg, Backman and Stigsdotter Neely (2008) also examined the level of cognitive plasticity in younger and older adults, to determine whether improved performance would transfer to untrained tasks. Thirty-two older and 32 younger adult participants were randomly assigned into two approximately equal groups; a training and control group. To assess the transfer effects of training, a battery of cognitive tests was administered at pretest, Posttest 1 (immediately after receiving training), and Posttest 2 (18 months after completing training). The tests included five cognitive tests: perceptual speed, working memory, episodic memory, verbal fluency, and reasoning. The results found that while older adults showed substantial training-related gains (comparable or greater than young adults), younger adults showed greater updating capacity and greater transfer effects in tasks requiring updating (Dahlin, Nyberg et al., 2008). Dahlin, Nyberg et al. believed this lack of transfer could be explained by the demonstrated lesser performance level in the updating skill proficiency of older adults, a level believed to be below that required for transfer to occur. This lack of transfer effect in older adults may also suggest that older adults have more limited neural capacity when compared to younger adults, a difference that appears to have been established in previous neurological research that demonstrated age-related alterations in striatal function (Dahlin, Stigsdotter Neely, Larsson, Backman, & Nyberg, 2008)

Research by Helene and Xavier (2006) that tested the level of transfer from both physical and mental practice using a mirror-reading task, found that physical and mental practice may also lead to different transfer effects. Results of the experiment suggested that acquisition of the mirror-reading skill was worse for the group given physical training compared to the group given imagery training. Helene and Xavier explained this as being the result of the extensive rehearsal of letters during training, which was believed to be less extensive during physical practice than mental practice.

However, Wohldmann, Healy and Bourne (2008) held that not all differences between physical and mental practice could be explained by the time-on-task hypothesis. To test this hypothesis, Wohldmann et al. explored the benefits to retention conferred by mental practice. Seventy-two undergraduate students were assigned to one of two training conditions (physical or mental). Five experimental phases were used: familiarisation,

immediate testing, training Part 1, training Part 2 and delayed testing. During a familiarisation phase, participants typed 4-digit numbers and took an immediate typing test on both old and new numbers. Participants then typed old 4 digit numbers, either physically or mentally, with the use of a different response configuration than used during familiarisation. On the delayed test, participants physically typed both old and new numbers with the same response configuration used during familiarisation. The results found were that mental practice lead to more transfer than did physical practice. These results were explained by the hypothesis that mental practice leads to less retroactive interference (i.e., impairment in the performance of previously learned motor skill performance, after new movements are executed) and that mental practice strengthens an abstract, conceptual representation of the task.

While this research is highly suggestive that some transfer of skills to a related task is possible it also appears that many extraneous influences may interfere with this transfer. Individual differences may impact on the level of transfer between related tasks, irrespective of the amount of practice an individual may have experienced or the degree of overlap of component processes the two tasks may share.

Which knowledge is transferred: component or merged knowledge?

Several major theories of skill acquisition assume that with extended practice component processes are melded together into larger knowledge configurations. Research conducted by Frensch (1991) examined which knowledge, component knowledge or merged knowledge was transferred following extended practice.

In his first experiment, Frensch (1991) examined whether manipulating the degree to which component knowledge could be composed in an initial learning task would affect performance on a transfer task. With the use of sixty undergraduate students, Frensch utilised a six-step mental arithmetic procedure, the Elio task (see Figure 1).

The Elio task is seen as a useful tool for studying transfer of cognitive skill because it has high external validity, is relatively simple and sequential, thereby forcing participants to adopt common serial strategies for performing the task. It is also suitable for collecting latency data and is easily modifiable. Therefore, the similarity and length of acquisition can be carefully controlled as can the transfer tasks (Frensch, 1991).

SOLID	ALGAE	LIME	TOXIN
		3	4
6	2	5	8
		1	7
		9	2
STEP:			
Index 1 = Solid * (Lime4 - Lime2)		1*	
Index 2 = Lime1min + (2 * Algae)		2	
Index 3 = Toxinmax + Toxinmin		3	
Index 4 = (Solid * 2) - Toxin4		4	
Index 5 = Greater of [(Lime3), (Toxin3 - Toxin2)]		5	
Overall Quality = 100 - Indexmax		6	

Figure 1. Basic screen setup for Elio task.

The experiment was divided into two phases: an acquisition phase and a transfer phase. To manipulate the degree to which component knowledge could be composed, subjects performed the original task (acquisition phase) in either a fixed, random or blocked sequence. In theory, this allowed participants in the fixed-sequence condition to compose within-step component knowledge but also component knowledge that crossed step boundaries. In contrast, subjects in random and block sequence conditions were allowed to compose within-step component knowledge, but not component knowledge that crossed step boundaries. Both the acquisition and transfer phases were tested at low and high practice levels (Frensch, 1991).

The results suggest that in the acquisition phase, blocked presentations led to faster performance than fixed presentations, which, in turn led to faster performance than random presentations. This is believed to have occurred because in the blocked phase fewer production rules were required, resulting in fewer production rules being required to be loaded into working memory. As the blocked-presentation condition was essentially a massed-practice condition in which the same step could be performed over and over again, there was no need to clear the contents of working memory. This prevented new information from having to be constantly reloaded into working memory (Frensch, 1991).

In the transfer phase, subjects in the fixed-presentation condition performed faster than subjects in either the block or random conditions. However, this advantage of fixed over random and blocked presentation was only apparent at high practice levels. Frensch (1991) explained this difference as being as a result of a) the degree of between-steps composition required for each different group, b) the degree of strengthening of production rules and c)

the number of newly learned production rules required for each group. In both the random and blocked-presentation conditions, participants needed to learn more new transition rules when performing the Elio task than did the fixed group and as both between-steps composition and strengthening require some practice, this difference is more pronounced in high practice conditions. This suggests that practice on a serial task results in the composition of basic component processes when the same sequence of component steps is repeatedly executed (Frensch, 1991).

In his second experiment, Frensch (1991) investigated the difference in transfer of knowledge that had been composed (i.e., high-practice condition) and knowledge that had not been composed (i.e., low practice condition.). Forty-four undergraduate students were also asked to perform the Elio task, which, like Experiment 1, also had an acquisition and transfer phase. The aim of the experiment was to establish the difference in the amount of transfer between knowledge that was composed and knowledge that was not.

The results suggested that composed knowledge can be transferred from one task to another and the amount of transfer at high levels of skill is better predicted by the amount of shared composed knowledge than by the amount of shared component knowledge (Frensch, 1991). Frensch (1991) interprets these results as a demonstration that the composition mechanism can provide a powerful explanation of the improvements in performance as a function of expertise and an important constraint on the process of transfer.

This research suggests that as a skill becomes more composed, and possibly moves towards automatised performance, the more readily the skill can then be transferred to another task. These results appear to offer some support for the hypothesis that automaticity is a catalyst for the improved transfer of skill.

Summary

The acquisition of skill is believed to occur in three stages the cognitive, associative and autonomous stages with the level of attentional effort required to complete a task believed to decrease through each subsequent stage. A distinction is also made between the controlled and automatic processes underlying cognitive tasks, with tasks requiring the greater cognitive effort deemed to involve controlled processes and tasks requiring very little cognitive effort believed to involve automatic processes.

Theories in Cognitive psychology state that the catalyst for this transition from controlled to automatic processing has been practice, a process that is believed to lead to automatic performance. The measure of automaticity or the point where automaticity is believed to have been achieved is determined by a statistical measure called the coefficient of variation (CV) or the standard deviation of RT divided by the mean reaction time ($SD/\text{mean RT}$).

An important area in skill acquisition research is transfer, or how training in one situation will improve the performance in another situation. The two major theories underlying skill acquisition transfer are Logan's instance theory and Anderson's ACT theory. Logan believes that transfer to a new related task is not possible, whereas Anderson believes that transfer from one task to another task is possible dependent on both tasks having basic underlying elements in common.

Hypotheses

The purpose of this project was to (i) identify whether increased task practice can lead to improved performance, (ii) whether increased practice will lead to automatised performance (iii) determine when performance on a task approaches automaticity and (iv) whether this point of automatisation can predict how an individual will perform on a new task. These hypotheses will be tested through the use of quantitative research project, that involves participants counting the number of stars on a display screen and determining whether the number is odd or even. The experiment will be divided into 2 phases, a training phase and a transfer phase. Participants will be allocated to a 10, 20, or 30 block design and will complete 80, 160, or 240 trials in training and 16 trials in transfer.

Two hypotheses relating to automaticity are a) that the amount of practice will correlate with automaticity (i.e., the more practice someone has had the greater the likelihood performance is automatic b) that individual differences will play a role and so the amount of practice will be too blunt a measure of how proficient someone has become at the task (e.g., some people will reach automaticity faster than others with equal practice).

Also examined will be whether there is disruption exhibited when old tasks are performed in a new context (Forbes, 2000; Giesen, 2000; Speelman and Kirsner, 2005) and whether the amount of such disruption is related to the extent of automatisation prior to transfer.

It is anticipated that the findings gathered from this research will assist trainers to determine when individual learners have reached a level of skilled performance, and consequently, are ready to progress to the next level of learning in the particular task, in their own time and at their own pace. It is hoped that the ability to detect this point or area of automatic performance could prevent children who learn a task quickly from becoming bored with the task and children who are slower to learn, from being overloaded with the task or progressed too quickly.

Method

Design

The theoretical framework used in the research was applied and quantitative with data for the research being collected via limited random convenience sampling. The experiment that received ethics approval from the Faculty of Human Ethics Subcommittee, Edith Cowan University, was divided into two phases: training and transfer. Training was comprised of blocks made up of 8 different and random trials, each comprising between 6 and 13 stars. The transfer phase included the same 8 trials with 6-13 stars patterns but also include between 1-4 red stars. Participants were assigned to one of three design groups, a 10, 20 or 30 block design (i.e., 80, 160 or 240 trials). Three groups were chosen to allow for the evaluation of the possible differences in each individual's RTs depending on the amount of practice they received.

Materials

The experiment was conducted in ECU's memory and cognition laboratory where computers were pre-loaded with Superlab software, which controlled the presentation of stimuli and collected the responses of participants. The stimuli consisted of a display screen of between 6 and 13 stars that participants were asked to count and choose, as quickly and accurately as possible, whether the number of stars in each stimulus was an odd or even number (see Appendix A). Participants were then required to record their selection by pressing the "odd" or "even" button on the response box.

During the transfer phase, two new blocks of trials were presented. Each transfer trial consisted of two parts. The first part was identical to trials during the training phase. That is, one of the original 8 experimental stimuli was presented and participants were asked to determine whether there was an odd or even number of stars. After they responded, a number of extra stars in red appeared on the original stimuli (see Appendix B) and

participants were again asked to decide whether an odd or even number of stars were present. After their response, the next trial commenced.

Participants

The 60 participants were university students recruited from the ECU campus and friends of the researcher conducting the experiment. All data collected from the 20 group (i.e., 19 participants) was discarded due to a computer programming error, as was data from two participants from the 30 group who it was considered had made too many selection errors, where participants chose the incorrect “odd” or “even” button. Overall data from 39 participants was used (20 participants in the 10 group and 19 participants in the 30 group). All participants were 18 years of age or over. With the use of convenience sampling through the use of flyers (see Appendix C) for 4th year psychology students and students from a participants list, participants were invited to participate in the experiment. Friends of the researcher were asked to participate by direct request. The order in which participants were tested was determined by their order of reply and their availability to attend the ECU Cognition Laboratory, where all experiments were to be conducted. All participants were given an introduction letter (see Appendix D) and accompanying consent form (see Appendix E).

Procedure

At testing, each individual participant was asked to complete a consent form and then informed of the requirements of the experiment; what they were required to do and what they could expect to occur during the experimental task. This was achieved through the use of a default instruction sheet (see Appendix F) that was read out to each participant prior to the experiment commencing. Any further questions a participant may then have were answered by reiterating the information on the default instruction sheet. Participants were then randomly assigned to one of three conditions, 10, 20 or 30 trial blocks and were left alone to complete the task.

On commencement the participants were met with the “ready” display on the screen where they were required to press the ready button on the response box once they were prepared to commence the task. One of eight stars displays then appeared on the screen (i.e., between 6 and 13 stars) with participants being required to count the stars on the screen, determine whether the number was odd or even, and press either the odd or even button on the response box. This process continued for 80, 160, or 240 trials depending on

which block design each individual was assigned to and was followed by 2 blocks (i.e., 16 trials) of transfer trials that consisted of one of the original training trials followed by a transfer trial. The transfer trial consisted of the same display as the training trial, but also included between 1 and 4 red stars added. The participants were again asked to count the number of stars on the display screen and determine whether the number of stars on the display were odd or even and press the relevant button on the response block. When all practice and transfer trials were completed, the screen became blank indicating to the participant that the experiment was over. Feedback was gathered from participants informally and occasionally, to determine if the participants felt the task became easier over time and whether they believed they counted the stars throughout the test or whether other techniques were used during the task.

Results

For all the analyses all RTs greater than 20000 msecs and less than 100 msecs were excluded from the data, as it was considered that such results would be as a result of anticipation or computer error. All incorrect “odd” or “even” selections were also excluded from the data.

The data was initially analysed by combining the RTs for each individual, block by block (i.e. participant 1 mean RT for block 1, participant 2 mean RT for block 1 etc). This was then completed for each block and overall group means were then taken for combined data for block 1, block 2 etc including transfer blocks. These times are presented in Figure 2. The results indicate that as the amount of practice increased, the mean RTs decreased for both the 10 block and the 30 block groups. The 30 block which included 160 more trials showed a greater amount of improvement than the 10 block, as indicated by the mean RT at the end of the 30 block training trials of ($M = 2698$ msecs) and the mean RT at the end of the 10 block training trial ($M = 3237$ msecs).

Results shown on Figure 2 also signalled that possible transfer had occurred in the 30 block as denoted by a lesser mean RT after block 1 of transfer trials ($M = 3338$ msecs) than the mean RT after block 1 of training trials ($M = 3491$ msecs). These results suggested that the participants in the 30 block were able to perform the specific task taught in this experiment, completely and more quickly during transfer than at the beginning of training, a believed indicator that transfer had occurred. This same level of improvement was not evident in the 10 block trial. To determine if the difference in means between transfer and early training was statistically significant a t test was conducted comparing the training and

transfer means for 30 block. The results were $t(18) = .65$, $a = .05$ which was not significant, signifying that transfer had, in fact, not occurred as visual analysis had implied. A t test was not conducted on the 10 block because transfer was not indicated by a lesser mean RT after block 1 of transfer trials than the mean RT after block 1 of training trials.

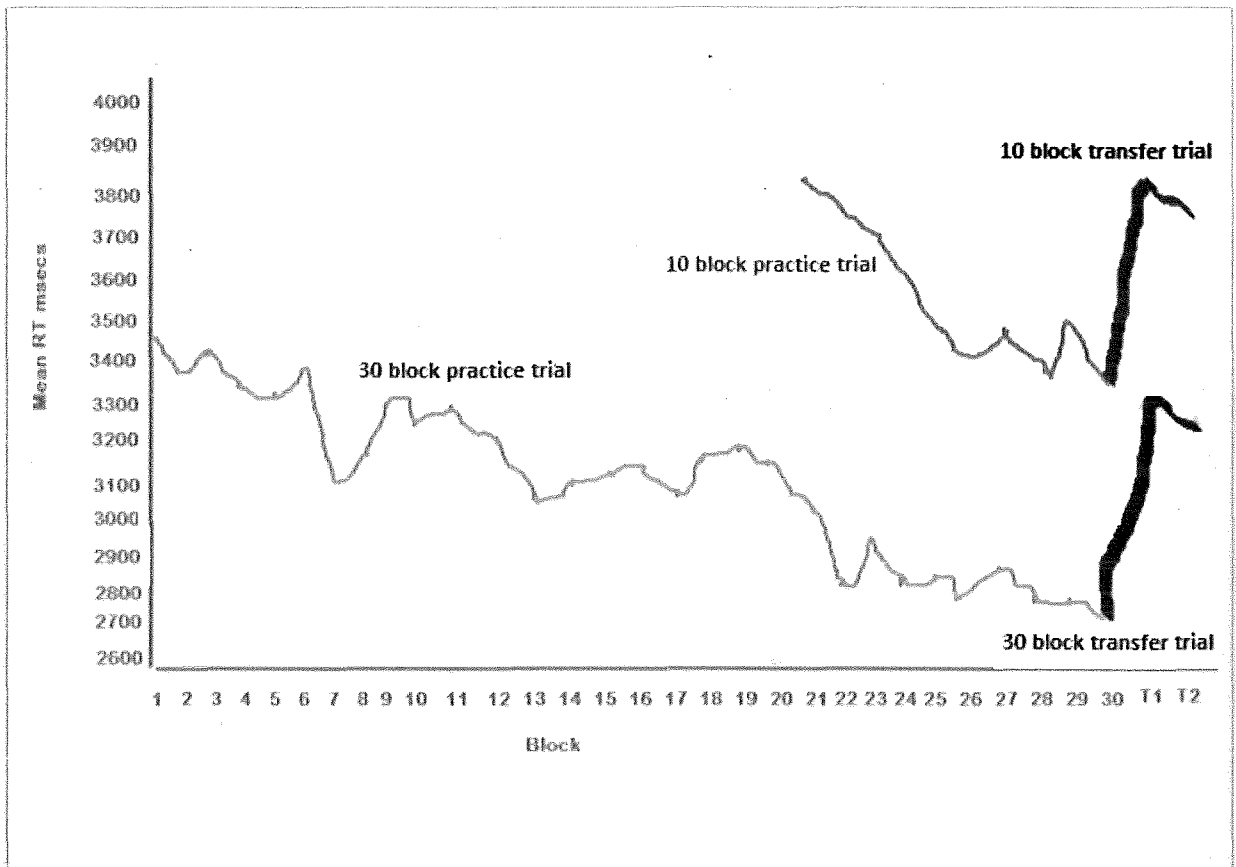


Figure 2. Comparisons of RTs between 10 and 30 block for training and transfer trials. T1 denotes transfer trial 1 and T2 transfer trial 2. Ten block practice (training) trials are means collected from blocks 1-10

Initial analysis also examined whether disruption of old stimuli experienced in a new context would be found and whether a greater amount of practice would lessen the effect of this disruption. Results indicated (see Figure 2) that both the 10 and 30 block design showed disruption and both groups showed proportionally similar levels of disruption despite the different amount of training both groups received. Calculations of the average disruption for both 10 block and 30 block were also conducted by subtracting each individuals mean RT from the final block of trials (i.e., block 10 for the 10 block design and block 30 for the 30 block design) from the mean of transfer trial 1. The average disruption for the 10 block was ($M = 579.79$ msecs) while the average disruption for the 30 block was ($M = 639.51$ msecs), suggesting that receiving more training did not lessen the

amount of disruption at transfer, but in fact, increased it. A Pearson’s correlation coefficient measure was also calculated between mean disruption for the final training trial for each block and the CV between final training trial and transfer trial 1, to determine if CV can predict the level of disruption. The results for the 10 block design were $r = .15$ and for the 30 block trial $r = .08$, suggesting that the CV did not predict the amount of disruption.

To determine whether participants were using counting or recognition techniques during the task, an analysis was conducted comparing the overall means for the first and last blocks of each design (e.g., blocks 1 & 10 for the 10 block design and blocks 1 & 30 for the 30 block design), comparing each of the 8 star displays. The results are shown on Figures 3 and 4. The results suggest that the participants in both the 10 and 30 block designs were almost exclusively counting the stars, as was shown by the linear increase in reaction times as the number of stars on the display increased.

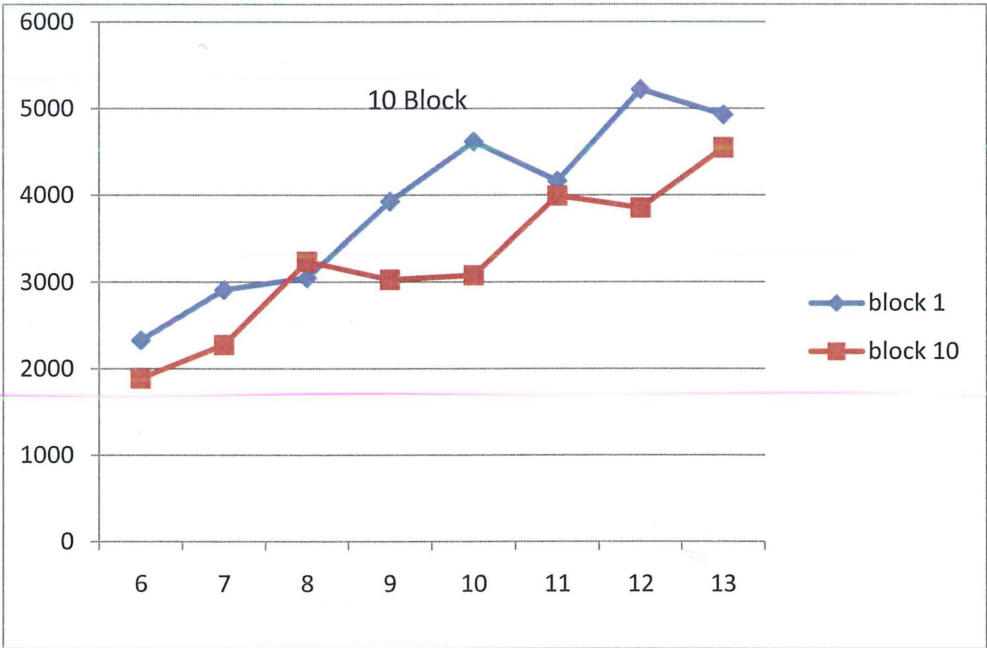


Figure 3. 10 block design individual stars for trial block 1 and trial block 10.

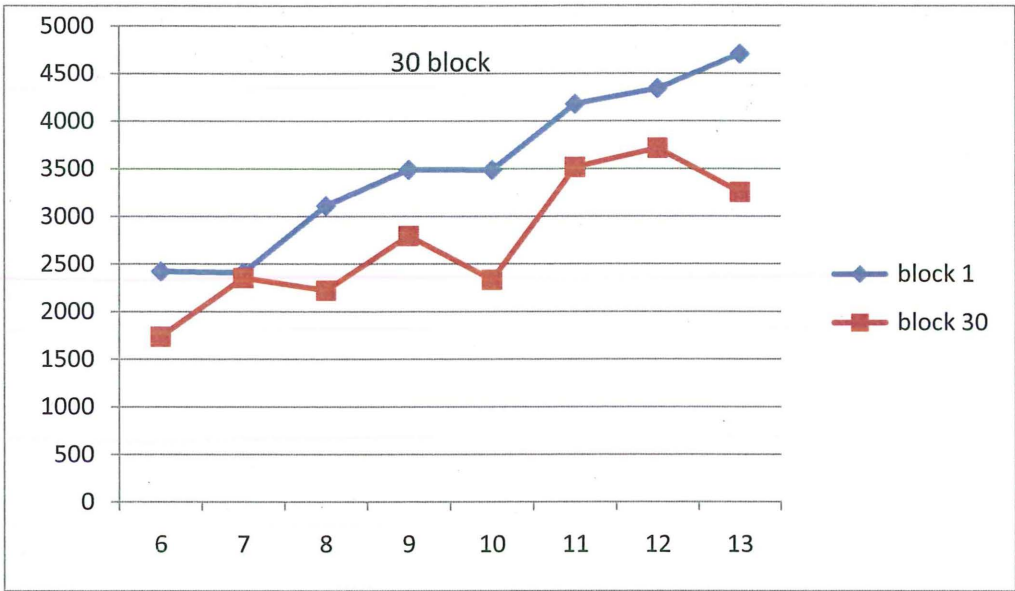


Figure 4. 30 block design individual stars for trial block 1 and trial block 30.

To determine whether a point of automaticity could be established from the experimental data, a CV measure which analysed the block means for both the 10 and 30 block groups was used. The CV was calculated by dividing the *SD*_{rt} by the individuals mean RTs. A decrease in the CV is believed to indicate a stabilising in the variability between mean RT and *SD*, a sign that automaticity had been achieved. The results are presented in Figure 5.

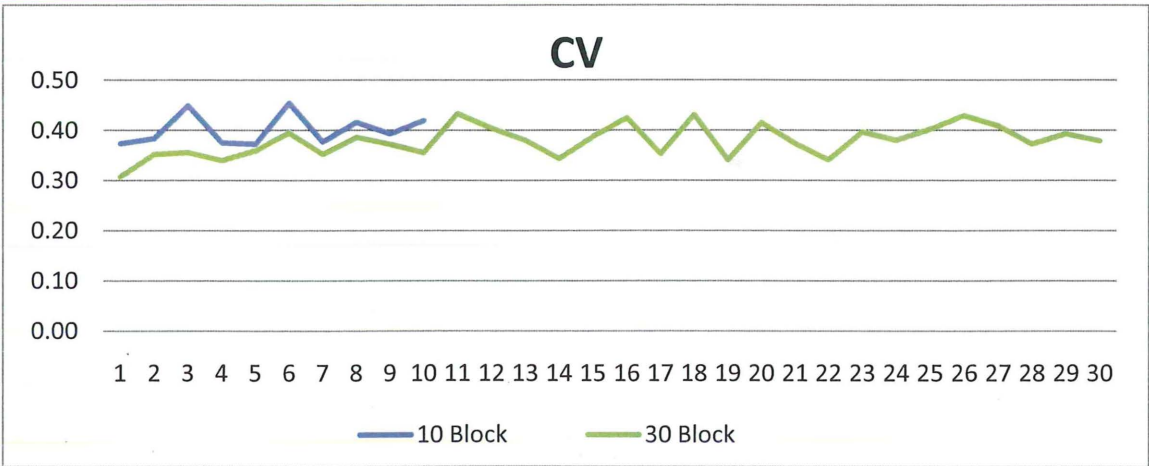


Figure 5. CV measures from 10 and 30 block show no decrease in CV values for the 10 or 30 block designs.

The results of the CV measures found that no decrease in the CV was evident for either the 10 or 30 block designs, suggesting that automaticity had not been realised.

Discussion

One area examined in this study was the hypothesis that participants who received the greatest amount of practice in a counting task would show improved RTs when compared to those who received less practice. This hypothesis was supported by the results of this experiment as shown in Figure 2, with a visual examination of RT means at the end of training for 30 block being found to be faster than the end of training RT for 10 block which received 160 less training trials. There were also indications of improved performance within both the 10 and 30 block designs themselves, when comparing the beginning of training RTs and the end of training RTs for each block design. This supports the suggestion that the greater amount of practice an individual receives towards a particular task, the greater the likelihood that they will develop improved performance on this task. This can usually be explained by either a speed-up of the component processes that underlie the task or the approaching or achieving of automatic performance (Segalowitz & Segalowitz, 1993).

It was also expected that this research study would discover that individuals who received the highest level of practice would be more likely to reach automatised performance or automaticity (i.e., participants who complete the 30 block trial would show greater automaticity than participants who complete the 10 block trial). However, this hypothesis was not supported by the results in this particular study. CV values did not decrease in line with increased practice, suggesting that, as determined by one measure of automaticity the CV, automaticity was not achieved (see Figure 5). Therefore, it may be tentatively suggested that the noted improvement in RTs in both the 10 and 30 block designs (as seen in Figure 2) are most likely attributable to the speed-up of component processes underlying the task (Hulstijn, Van Gelderen & Schoonen, 2009; Segalowitz & Segalowitz, 1993). or in other words, simply faster counting.

To further investigate whether speed-up in counting as opposed to the use of recognition techniques were being used by participants, an analysis of each star was conducted (see Figures 3 & 4). The results suggested that counting was occurring, as indicated the linear increase in RTs as the number of stars presented increased. This offered further support for the proposal that as automatic performance as measured by the CV, had not been achieved,

the improved performance noted in both the 10 and 30 block designs (as shown in Figure 2) may have been as a result of the participants faster counting of the star displays only. However, it should also be noted that while counting techniques appear to have been used almost exclusively through the experimental task, the trial block 30 line (see Figure 4) did appear to show a hint of automatic performance (i.e., flattening or downturn of the line). However, this downturn was inconsistent and appeared to occur for some stars and not for others, implying that while participants were using counting for certain stars, they may have been using alternative techniques for other stars. These alternative techniques could include either direct recall from memory or the detection of distinctive features in the display structure for particular stars (e.g., 10 stars & 13 stars), where both patterns appear to be separated into two distinctive sections and groupings (see Appendix G). Presumably, this made quicker identification of these particular star displays more easily achievable than stars that were in a single grouping (e.g., 8 and 11 star displays) (see Appendix H). Further evidence of possible recognition rather than counting may also be apparent for the 10 star display in the 10 block, which also showed a hint of flattening of the line at the 10 star point (see Figure 3). This further suggests that the 10 star display (see Appendix G) may have contained unique features that allowed participants to recognise it more quickly than the other stars presented, enabling participants to quickly achieve automatised performance with the 10 star display, but not other star displays. However, why the same result did not apply to the 7 star display (see Appendix I) that contained these same distinctive features with even less stars to count, is unclear. A possible explanation is that, as it would have taken such little time to count so few stars from the outset, any time saved through the development of recognition techniques used for the 7 star display may have been so small as to be almost undetectable.

This study also addressed whether participants who had received the greatest amount of practice (i.e., possibly moving towards or attaining automatised performance) would be more likely to show transfer effects from the training task to the transfer task. Transfer was expected to be denoted by the RT at transfer being faster than the reaction time at early practice. A *t* test performed comparing the means of early training and early transfer in the 30 block design was found to be not significant ($\alpha = .05$). This is possibly best explained by the fact that automatic performance or automaticity, an important catalyst for improved transfer, had not been achieved during the experimental task and consequently, transfer was less likely to occur (Frensch, 1991).

Another possible explanation for this lack of transfer is the disruption caused by the change of context during the transfer trials (Giesen, 2000; Speelman & Kirsner, 2005). It

appears that the disruption experienced during transfer, did not enable participants to maintain their previous learning gains for the original task. This may be explained by the fact that as automatic performance had not been achieved during training, which would have allowed for the use of less attentional resources on the original stimulus during transfer, much of the attentional resources that were previously being used to process the original task were now being directed towards processing the new transfer task, making maintenance of the same level of performance on the original task more difficult to achieve.

A further potential explanation for the inability of participants to achieve transfer in this particular task was the lack of variability in the training task. Research by Stokes, Lai, Holtz, Rigsbee and Cherrick (2008) suggests that variability during training prepares the learner for possible change that they may encounter later in the training task or during transfer. It appears the lack of variability available during training for this particular task did not sufficiently prepare participants for the differences during the transfer phase and as such, participants were not sensitised to variation when the change of context occurred in the transfer trials.

A final possible explanation for the lack of transfer in this experimental study was the nature of the task involved in the experiment. Research by Speelman and Kirsner (2005) suggests that transfer is most likely to occur when the task being practiced has had sufficient time to become composed (i.e., collapsing of levels within the task). As the task used in this particular experiment was a simple task with few levels of complexity and was not sequential in structure, (which would have forced participants to adopt common serial strategies for performing the task), it may be suggested that the simplicity of the task meant that composition was less likely to occur. This effectively eliminated a second means by which, participants were able to attain automatic performance (i.e., automatic performance would have to be achieved through direct retrieval from memory, or it would not be achieved at all).

It was also anticipated in the research study conducted, that participants' RT on the old stimuli in the transfer task (i.e., the end of the first transfer trial) would be slower than RT at the end of the training as a result of contextual disruption (Speelman & Kirsner, 2005). This hypothesis was supported by the visual appraisal of the results which examined the group mean RTs comparing the practice trials with the transfer trials. It was also suspected that the greater the practice received the less disruption could be expected. This hypothesis was not supported by the results, with the 10 block showing a lower average disruption score than the 30 block that had received 160 extra training trials during training. This suggests that the amount of practice received prior to an old stimulus being presented in a new context, does

not influence the amount of disruption experienced. This may be explained by fatigue as the participants who had completed the 30 block trial had completed 160 more training trials than participants completing the 10 block and consequently may have had less mental resources remaining with which to deal with the change in context during the transfer trials.

Alternatively, it is possible that the 30 block participants had achieved a greater level of routine in performance after completing these extra 160 training trials. As variability in training is seen as a catalyst for improved performance during transfer (Stokes, Lai, Holtz, Rigsbee & Cherrick, 2008), it is possible that the more routine a performance has become during practice the more difficult participants may find it to counter a sudden change in context.

What should also be considered regarding the impact of disruption on transfer for this task is that, as the average level of disruption was higher for the 30 block than the 10 block (suggesting that more practice leads to greater disruption), it is unclear whether any level of practice would have been sufficient to overcome the disruption and enable transfer to occur. However, previous research examining the impact of contextual change on transfer conducted by Giesen (2000) suggests that the effect of disruption on transfer may only be temporary, unless the change in context is so dramatic as to necessitate the re-evaluation of the task requirements, therefore, it could be expected that more usual practice/transfer outcomes as noted in previous studies, would most likely ensue.

Limitations

The foremost limitation of this research study was the number of participants that were used in the study. While 60 participants were originally intended to be included, a programming error meant that all data from participants from 20 block (i.e., 19 participants) were excluded from the analyses, notably affecting the power of the research results. Unfortunately, time prevented new testing of participants to be performed and therefore, a future study with the full complement of participants may need to be conducted to consolidate the findings in this research.

Another limitation of the research was the inability to allocate participants in a completely random manner to a particular condition. (i.e., it was sometimes necessary to give a person the shortest task because of time restraints or the participants' refusal to participate if it took over a certain amount of time). This may have contributed to the result where two different groups who had completed the same task for the first ten blocks of the task, achieved significantly

different results from the other group. Future studies will need to ensure that randomisation is strictly followed for all participants participating in the research.

Another area of this research that may need to be examined is the star patterns of the displays. It appears certain star displays contained features that distinguished them from other star displays, making any noted improvement in the task more erratic and unpredictable than was possibly anticipated. More generic patterns that make star patterns more similar in appearance may be required to help resolve this inconsistency.

Implications of the research

It was anticipated that the findings gathered from this research would assist trainers to determine when individual learners had reached a level of skilled performance, and consequently ready to progress to the next level of learning in the particular task, in their own time and at their own pace. It was hoped that the ability to detect this point or area of automatic performance could prevent children who learn a task quickly from becoming bored with the task and children who are slower to learn, from being overloaded with the task or progressed too quickly. What this research ultimately demonstrated, is that in some instances, much practice is needed when completing certain tasks and that the influences of contextual disruption, task structure and the type of training a person receives, can impact on when automatic performance is achieved. These results have implications for any future research that continues to search for the point of automaticity, in how future studies and experimental tasks may need to be structured and how peripheral influences may need to be accommodated, to achieve its aim.

Conclusions

The main objective of this particular research study was to determine the point of optimum transferability of skill. Past research suggested that this point may be determined after participants had received sufficient practice and had reached a level of automatic performance. However, this study was unable to achieve this objective. Results obtained from this study suggest that the amount of practice participants receive in this experimental task was insufficient to achieve automatic performance, as measured by the CV procedure, and in turn possible transfer. This was indicated by the failure of the data to show a decrease in the CV over the practice trials, the fact that the disruption caused by the change of context in the transfer trials was sufficient to prevent transfer from occurring and also that participants continued to use counting techniques, rather than recognition or composition techniques,

almost exclusively through both the 10 and 30 block designs. As a result of these findings it appears that for automatic performance to emerge in this particular task, future research may need to consider using more than 30 blocks of trials in the study. It is expected that further practice will enable automatic performance to be reached and resultant transfer to be achieved. This would allow for further examination and analysis of a series of CV measures at a time when automaticity has been achieved and a determination of when a satisfactory level of SDrt/ mean RT stability has been achieved.

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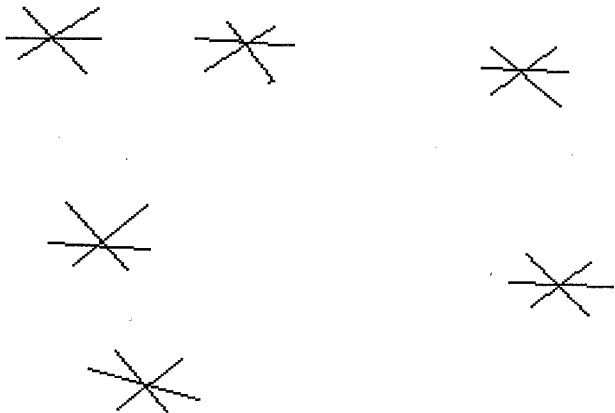
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Appendix A

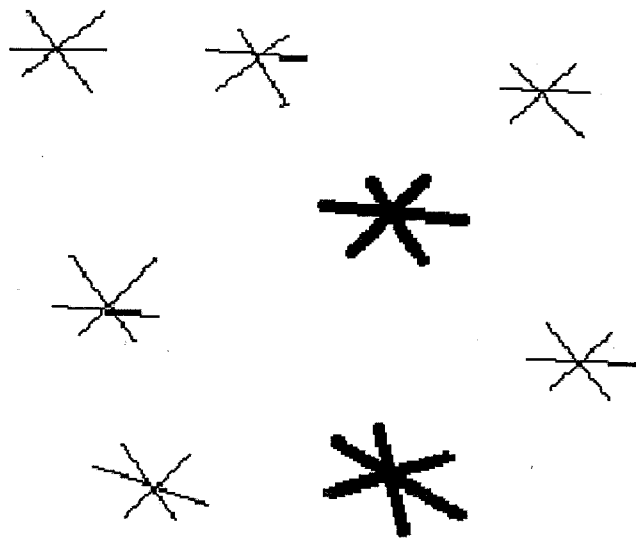
Template for experimental stimuli



ODD EVEN

Appendix B

Template for transfer stimuli



ODD

EVEN

Note: Two star are presented in red colour.

Appendix C



**ECU School of Psychology and Social Science will soon be Conducting a
Counting Experiment**

**This computer based experiment will be conducted in CogLab Building 30 (opposite
the computer lab) All are encouraged to participate and participation would be
greatly appreciated**

To express your interest please contact:

[Redacted contact information]
[Redacted contact information]
[Redacted contact information]

Note. Flyer used for the recruitment of participants via email or personally delivered.

Appendix D

Information Letter

My name is Amanda Puchar and I am currently completing my Honours in Psychology at Edith Cowan University, Joondalup Campus. This project is being undertaken as part of the requirement for my Psychology Honours Degree. I appreciate your interest in being part of this study and your input is valuable.

The purpose of this study is to examine how practice improves performance on simple cognitive tasks. It is anticipated that the task that you are required to complete will take approximately half an hour. It will be carried out in the memory and cognition laboratory inside the ECU School of Psychology and Social Science. You will be required to complete a star counting task. The star counting task requires you to count the number of stars and respond by pressing the odd or even button on the response box available. The time take to complete the task and the accuracy of it will be recorded.

Any information collected during the study will remain strictly confidential with any identifying information being omitted from my final research presentation. Information collected from the study may be used in future research. Your identity will not be disclosed at any time. It will be protected and not be published in any reports. Once the task is completed, the information collected will be downloaded into a thumbdrive and will be stored securely at the University site.

Your involvement in this study is voluntary and you are able to withdraw at any time. No explanation and justification is necessary. If you withdraw from the research, you also have the right to withdraw any information that has already been collected.

If you do have interest about the outcome of the research project, I will be pleased to share it with you upon its completion which is scheduled on 29 October 2010. My contact number will be listed below.

If you are interested in participating in this research, it is required of you to complete the informed consent document before participating in the study. Once completed it can be returned to the office of the School of Psychology and Social Science Building 30, ECU Joondalup or returned to me at [REDACTED] This study has been approved by the ethics committee.

If you do have any questions about the research or any further information about the project, do not hesitate to contact me (details attached), or my supervisor, Professor Craig Speelman (6304 5724). However, if you do wish to speak to someone who is independent of this research project, please contact the fourth year coordinator, Dr Justine Dandy (6304 5105).

Thank you for taking the time to consider being part of this research. It is greatly appreciated.

Contact details:

Amanda Puchar

[REDACTED]

[REDACTED]

Appendix E

Participant consent form

I, _____ have read the information sheet provided and agree to participate in the research conducted by Amanda Puchar of Edith Cowan University. I have read the information letter and have understood the purpose and nature of the study. My participation is voluntarily. Any queries I had have been answered to my satisfaction and I grant the permission for the information collected to be used in the process of completing a Honours Psychology degree and acknowledge that it may be published. I understand that my name and any other personal information which may identify me will not be used. I understand that the information collected from this experiment will be used in future research. I understand that I can withdraw from the research at any time without any explanation or justification.

Research Participant

Date

Primary Researcher

Date

Appendix F

Instruction letter

Thank you for your interest in and giving your time to participate in this research.

For this experiment you will be required to complete a simple counting task. A series of display screens will be shown to you with a number of stars on them. Your task is to count the stars on the screen and indicate whether there are an 'ODD' or 'EVEN' number of items by pressing the allocated buttons on the response pad.

To begin the task a "READY" screen will be displayed. Please press the TOP LEFT hand button on the response pad when you are ready to begin. The first display screen will appear immediately after your response.

If you determine the number of stars in the display to be an 'ODD' number, please indicate by pressing the BOTTOM LEFT button on the response pad marked "ODD".

If you determine the number of stars in the display to be an 'EVEN' number, please indicate by pressing the BOTTOM RIGHT button on the response pad marked "EVEN".

It is important for you to be as fast and accurate as possible.

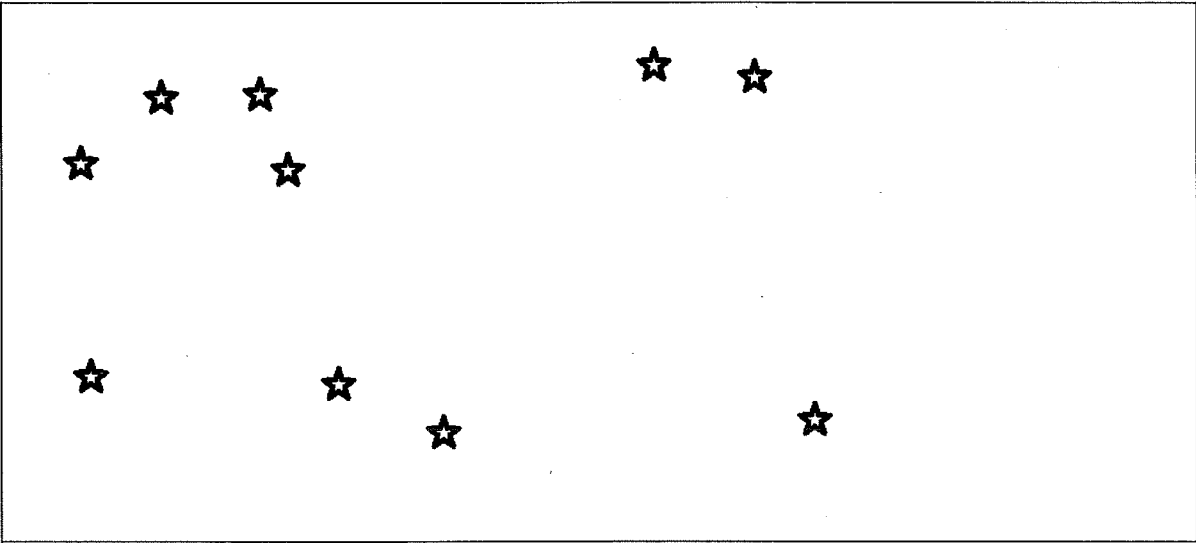
At some point during the experiment, there will be a slight change in the display. However, your task remains unchanged. That is to say you must count ALL items in the display and respond 'ODD' or 'EVEN' accordingly.

Do you have any questions?

Please begin the experiment by pressing the "READY" button when you are ready to begin.

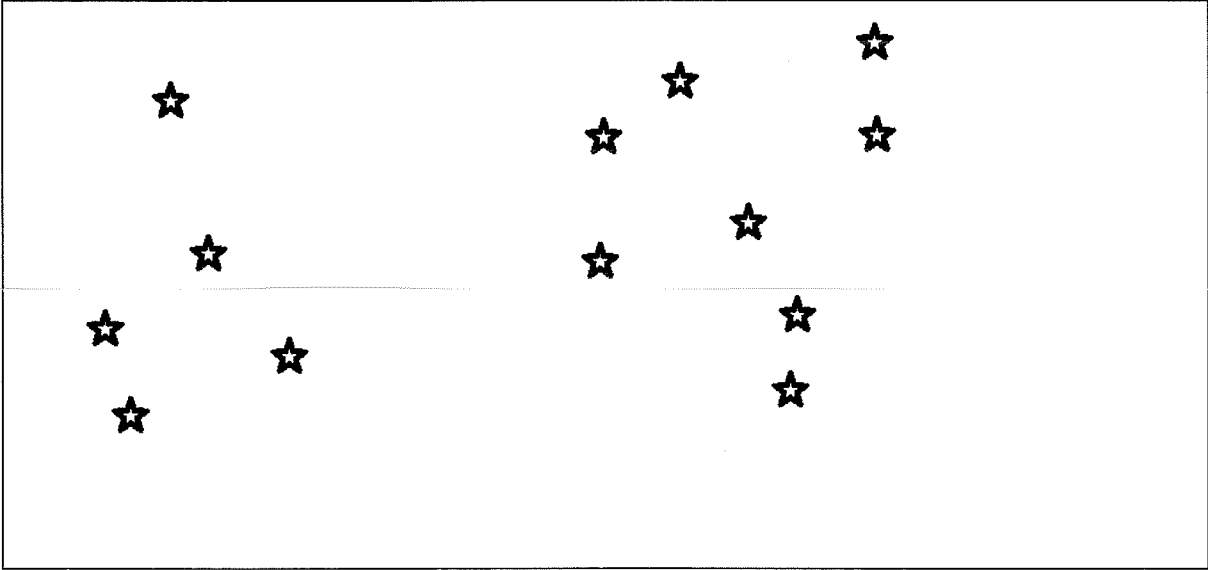
Appendix G

10 star display pattern



Note: The 10 star display is a distinctive pattern possible making identification easier.

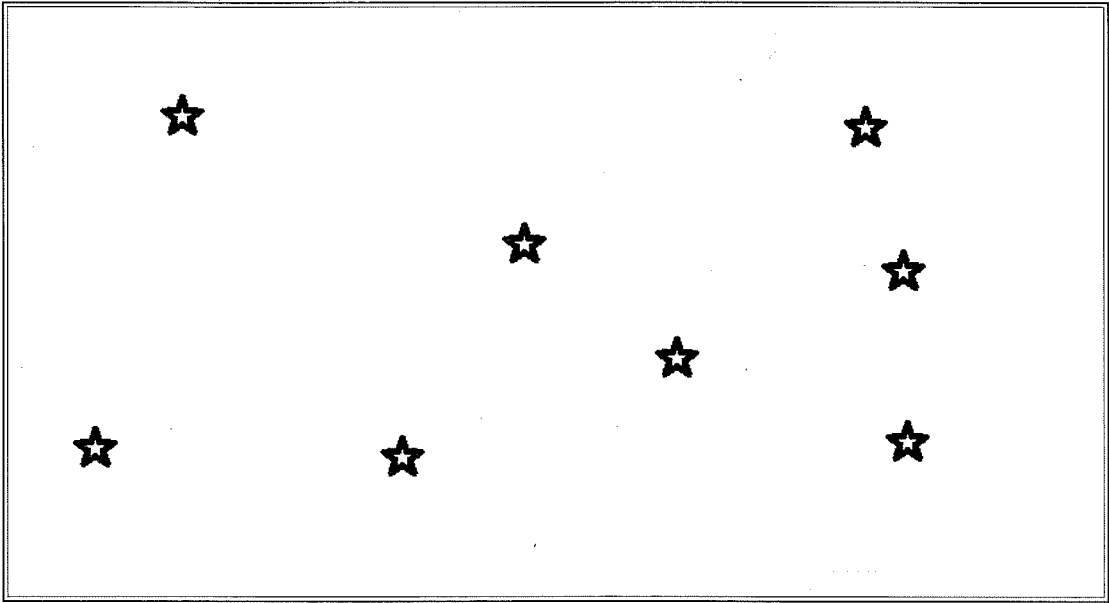
13 star display pattern



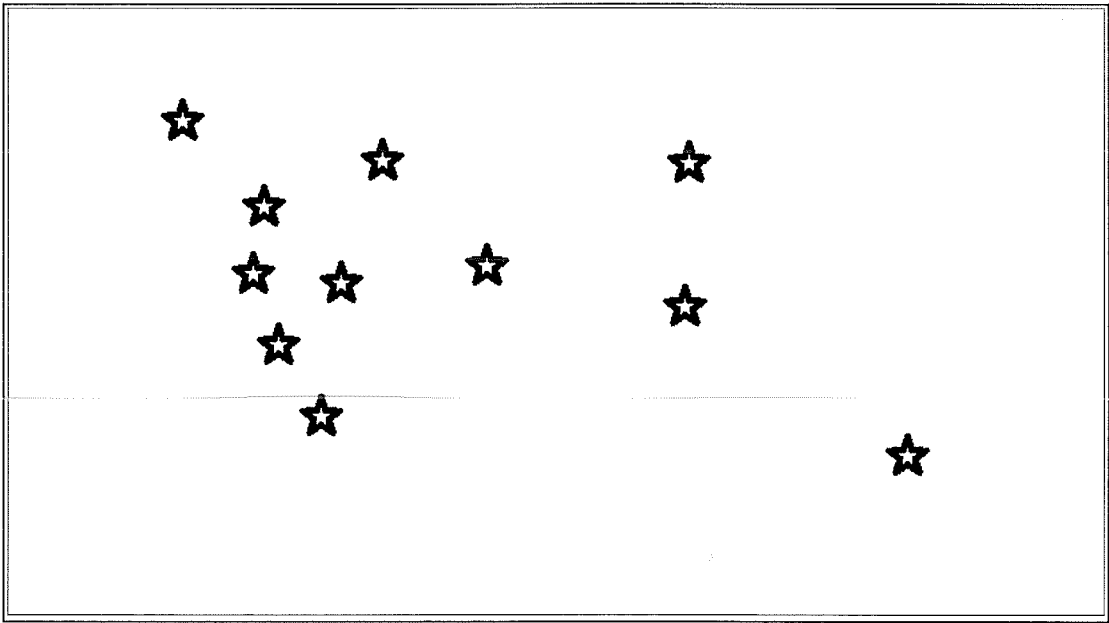
Note: The star display is divided into two separate groups allowing for chunking or easier identification.

Appendix H.

8 star display



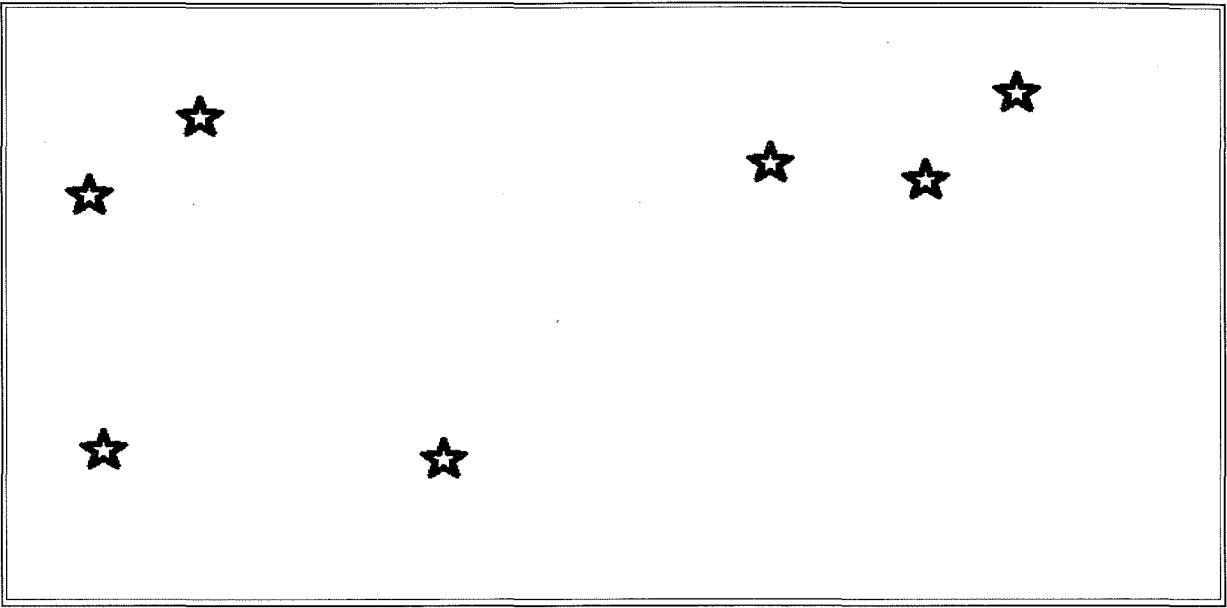
11 star display



Note. The 8 and 11 star displays are in more of a single grouping without any stand out features, making the patterns less distinctive.

Appendix I.

Seven star display pattern



Note. The 7 star display also appears to show a pattern that is in two distinctive groups, yet no automatic performance was noted for this display.