

Tower of London

Sanzen Neuropsychological Assessment Tests

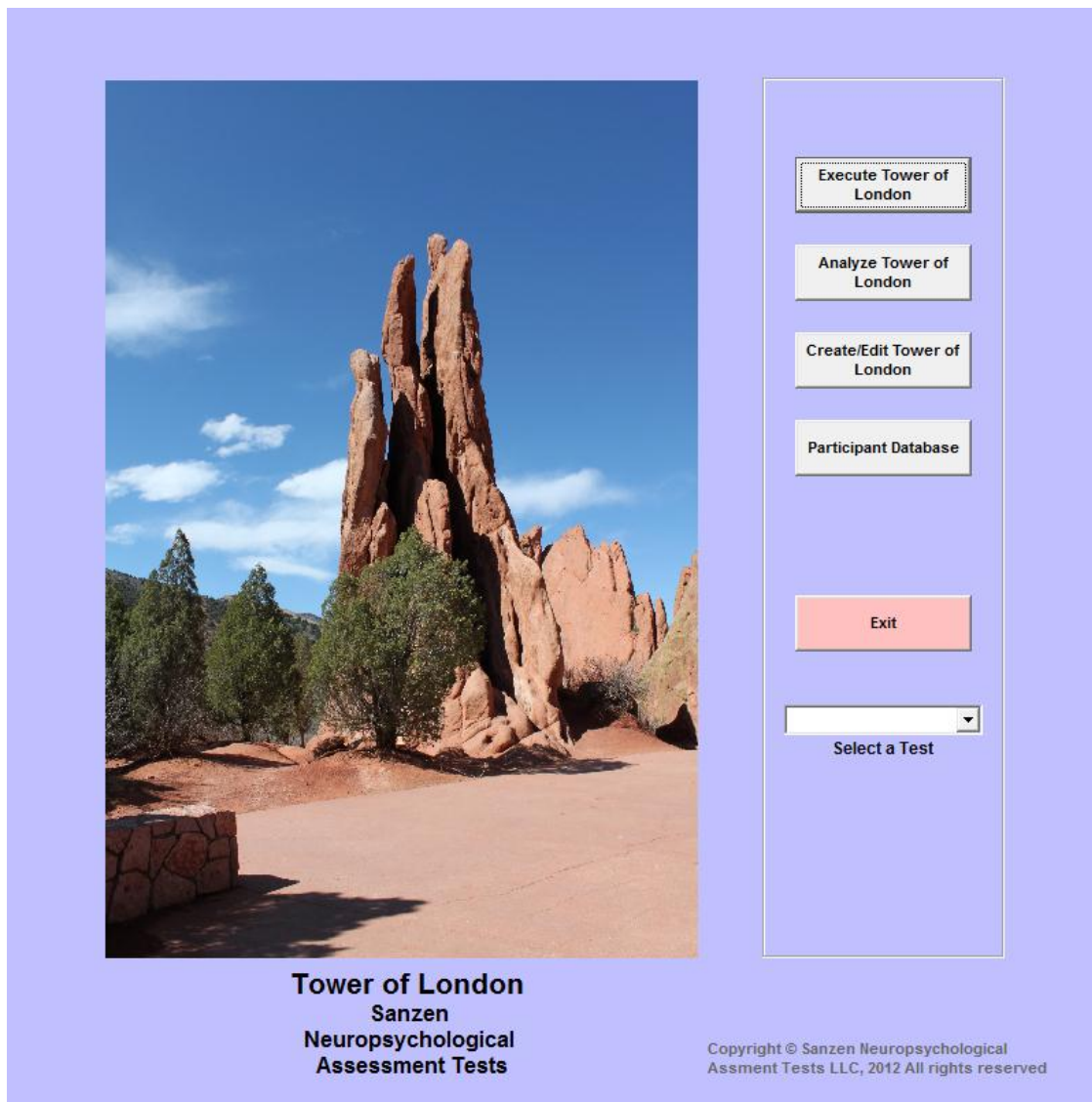


Figure 1

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SANZEN Neuropsychological Assessment Tests' Tower of London Test

The SANZEN Tower of London test establishes a new standard of excellence in computerized assessment tests. SANZEN Neuropsychological Assessment Testsq **Tower of London** comes with two pre-programmed Tower of London tests, but then offers the user flexibility in either modifying these pre-loaded tests or creating new tests from scratch. The Sanzen Tower of London test has enough flexibility to program any of the problem sets currently being used in cognitive or neuropsychological research and assessment (i.e., Culbertson and Zillmer, 1998; Berg and Byrd, 2002).

Design options include the choice of three to five pegs and a custom color palette for beads. Response modalities include both touch screen and mouse . the latter offering either a point and click option or a slide bar option.

Trials can be specified as either timed (i.e., the trial is terminated after a predetermined amount of time has elapsed) or untimed. Trials can also be set to terminate after a specified number of moves.

Custom instructions can be written for each trial; and even the few built-in directional messages can be altered to reflect the language needs of the participant population.

The analysis screen provides the user with a running record of all relevant test events including all stimulus events, participant responses, and the time (to the nearest millisecond) that the system detected the event, as well as a trial-by-trial analysis of participant performance and a summation of performance across trials. A playback feature allows the user to review the sequence of moves made by the participant in solving the problem on any trial.

As part of an ongoing research program, a substantial number of test results have been obtained using a SANZEN computerized version of the Tower of London test. The descriptive statistics, broken out in ten year cohorts for those test results, are provided at the end of this manual in the %normative data+section.

Introduction: The Tower of London

Problem solving, a skill used by people of all ages to reach goals and complete tasks, has long attracted the attention of cognitive psychologist and neuropsychologist.

Shallice (1982) developed the Tower of London (TOL) task to measure planning and problem solving skills in patients with damage to the frontal lobes. Patients and control subjects were presented with a model where three beads were strategically positioned on three rods of descending heights. Participants were then asked to manipulate beads from a predetermined starting position on a different set of pegs to match the position of beads in the model. In Shallice's study, problem solving ability was determined by the number of excess moves made on the TOL problems. That is, the number of additional moves above the minimum number of moves needed to solve the problem was the dependent measure of problem solving. The larger the number of excess moves, the poorer the problem solving ability. Shallice found that individuals with lesions in their left anterior frontal lobe made more errors and had longer planning times than members of a control group. Much of the subsequent research using the TOL has also focused on the problem solving ability of individuals with brain damage and/or head trauma (e.g., Shum, Gill, Banks, Maujean, Griffin, & Ward, 2009). In general, for head injured patients findings mirror Shallice's results which indicate that damage to the prefrontal cortex impairs problem solving ability.

While the ecological validity of the TOL has been questioned by some researchers (Philips et al., 2006), it is still widely used to compare the problem solving and planning ability of typically developing individuals to individuals with genetic disorders (Azadi, Seddigh, Tehrani-Doost, Alaghband-Rad, & Ashrafi, 2009), mental health disorders such as autism (Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009), attention-deficit hyperactivity disorder (Riccio, Wolfe, Romine, Davis, & Sullivan, 2004), dementia (Marchegiani, Giannelli, & ODeti, 2010), and/or schizophrenia (Morris, Rushe, Woodruffe, P.W.R., & Murray, 1995), to note a few. These studies have established normative baseline data and measured the extent to which TOL problem solving performance differs in clinical versus non-clinical populations.

In order to accurately measure the problem solving ability of people with physical or mental health problems, variations of Shallice's original TOL have been created. For instance, some researchers use computerized versions of the TOL (Bugg et al., 2006; Ouellet et al., 2004) while others use an actual board with pegs and beads that the participant can physically manipulate (Anderson, Anderson, & Lajoie, 1996; Baker et al., 2001; Culbertson & Zillmer, 1998; Krikorian, Bartok, & Gay, 1994). The minimum number of moves needed to solve each problem varies across studies and ranges anywhere from two (Luciana & Nelson, 1998) to eight moves (Raizner et al., 2006). Also, many studies use different methodologies and measure different aspects of planning and problem solving performance. For example, some researchers use the number of excess moves to measure performance while others use a perfect solution score (the number or percentage of problems correctly solved using the minimum number of moves), the total cognition time (this variable represents the total time that the participant is not holding a bead after the first move is made), the initial think time (this represents the time from when the problem is first displayed to when the first move is made), or the total move time (the amount of time that the participant spends per problem holding onto a bead). Given that a wide range of dependent measures have been used to evaluate the various aspects of planning and problem solving performance, one must use caution when interpreting the findings and making inferences about the development and decline of problem solving ability. The computerized SANZEN TOL computes the typical dependent variables used in studies examining TOL performance. The results printout for the SANZEN TOL test gives the number of excess moves for each problem, the initial think time before the initial move is made for each problem, the total think time on each problem, and the time taken to successfully complete each problem. Figure 8 (on page 24) shows a typical printout of results.

Magnetic resonance imaging (MRI) studies suggest that the prefrontal cortex area takes longer to develop than most brain areas and does not fully mature until the early 20s (Geidd, 2004). Age-related declines in frontal lobe functioning and volume, suggest that this area may be one of the first brain areas to decline with increased age (Haug, Barmwater, Eggers, Fischer, Kuhl, & N. L. Sass, 1983). Accordingly, problem-solving

abilities should show full development in the twenties and decline in late life, but the literature contains mixed findings. Normative data has been collected in studies using different age groups such as children (e.g., Luciana, Collins, Olson, & Schissel, 2009), adults (e.g., Byrd, Case, & Berg, 2011), and older adults (e.g., Andres & Van Der Linden, 2000; Phillips, Smith, & Gilhooly, 2002). The majority of samples found in the problem solving literature are mostly limited to children, adolescents, young adults, and college students. Few studies investigate the problem solving performance of mid-aged adults and older adults. With the exception of the research described in this manual, there are no studies with large sample sizes that investigate the use of the TOL as a measure of problem solving performance across the lifespan.

The literature on the TOL problem solving performance of children and young adults demonstrates some consistent developmental patterns. In general, young children demonstrate poor problem-solving performance, but as they develop their problem-solving performance improves (Luciana et al., 2009). Some researchers have suggested that there are periods during childhood and adolescence in which children display a developmental ~~%spurt+~~spurt in problem solving ability. For instance, between the ages of four and five (Luciana & Nelson, 1998), seven and eight, and at age 12 (Anderson, Anderson, & Lajoie, 1996), there is a significant increase in problem solving performance. The discoveries of developmental spurts in problem solving performance on the TOL beg the question: why do older children generally perform better than younger aged children? Luciana and Nelson suggest that young children have yet to develop the ability to plan and use effective strategies that guide working memory processes. Other researchers have proposed that children are unable to search ahead (Kaller, Rahm, Spreer, Mader, & Unterrainer, 2008). As for reaching asymptotic performance, researchers suggest that problem solving peaks during adolescence (Asato, Sweeney, & Luna, 2006; Baker, K., Segalowitz, S. J., & Ferlisi, M., 2001; Luciana, M., Collins, P. F., Olson, E. A., & Schissel, A. M., 2009; Ward, H., Shum, D., McKinlay, L., Baker-Tweney, S., & Wallace, G., 2005), the 20s (Huizinga, Dolan, & Van Der Molen, 2006).

The literature does not offer a clear idea as to when problem solving performance on the TOL begins to decline. Typically, studies have compared a young group in their 20s to an elderly group of individuals 60+ years of age making it difficult to determine when age deficits first appear on the TOL. However, clear age effects between young and older adults have been detected on the TOL. Phillips and colleagues have shown that older adults perform worse on the TOL than younger aged adults (Phillips et al., 2006; Phillips et al., 2002).

Intrapersonal Factors that Affect Problem Solving Performance

The TOL literature has consistently linked a wide array of intrapersonal factors to TOL performance. Some of the more commonly investigated factors include age, fluid intelligence, speed of processing, planning time, and executive functions such as response inhibition, working memory, and shifting. The following subsections will describe each of these variables and the amount of influence they exert on TOL performance.

Age. The participants' age has been identified as a variable that predicts problem solving performance on the TOL. The literature contains mixed findings as researchers have found the effect size for age to range anywhere from medium (Anderson et al., 1996; Bugg et al., 2006; Robbins et al., 1998) to large (Bull et al., 2004; Huizinga et al., 2006; Kaller et al., 2008; Krikorian et al., 1994; Luciana et al., 2009; Luciana & Nelson, 1998; Ward et al., 2005; Zook et al., 2006). Although there are clear age differences in TOL performance (i.e., young children to adolescents and adolescents to young adults), it is possible that other variables may explain the variation in problem solving performance across different age groups. For instance, some researchers found evidence suggesting that fluid intelligence mediates the relationship between age and problem solving performance (Zook et al., 2006). These researchers used an analysis of covariance (ANCOVA) and found the age effect on problem solving performance disappeared when fluid intelligence was statistically controlled for. Although the sample size was small and only consisted of older adults, this study highlights the possibility

that age itself might not be a sufficient predictor of problem solving performance on the TOL.

Fluid intelligence. Out of all the intrapersonal variables, fluid intelligences appears to have the strongest effect on problem solving performance as the vast majority of the effect sizes found in past studies were large (Unterrainer et al., 2004; Zook et al., 2004; Zook et al., 2006). Fluid intelligence involves the ability to reason and think abstractly; both of which are required when planning and solving TOL problems. Higher scores in fluid intelligence are associated with better performance in problem solving tasks (Unterrainer et al., 2004; Zook et al., 2004; Zook et al., 2006) while other measures of intelligence such as verbal (Unterrainer et al., 2004) and full-scale intelligence (Luciana et al., 2009) were not. This further supports the notion that fluid intelligence specifically, best predicts problem solving performance.

Past research indicates a possible overlap between fluid intelligence and other variables that have been linked to TOL performance. For instance, it has been suggested that fluid intelligence and executive functions utilize similar cognitive processes (Goldstein and Green, 1995). Other intrapersonal factors such as processing speed (Bugg et al., 2006) and age (Zook et al., 2006) have also been linked to performance on both fluid intelligence measures and TOL performance. Compared to fluid intelligence, the effect of these other intrapersonal variables on TOL performance appears to be weaker. In short, the relationship between other related intrapersonal factors and performance on the TOL may be mediated by fluid intelligence. To date, only one group of researchers has examined this possibility. In their study, Zook et al. (2006) found that fluid intelligence mediates the relationship between age and TOL problem solving performance. Given the limitations of this study, more research will be needed to better understand the relationship between fluid intelligence, its related intrapersonal variables, and problem solving performance on the TOL. The samples used in future studies should be larger in size and contain representations of all age groups (i.e., children, adolescents, young adults, mid-aged adults, and for replication purposes, older adults).

Processing speed. Speed of processing has been theorized to account for age related changes in cognition (Salthouse, 1996). Specifically, cognitive processing is degraded because required operations cannot be accomplished within a restricted time frame and the loss of early stage processing (results) during later stage processing. The literature on the effect of processing speed on TOL performance is limited and the evidence is mixed (Asato et al., 2006; Phillips et al., 2006). For instance, Phillips and colleagues found higher levels of processing speed are associated with a decreased number of errors (excess moves). Asato et al. (2006) found that speed of processing moderately affected performance on TOL problems that could be solved in four moves (the effect size was .08). These findings were not supported across other TOL problems which contained a different number of minimum moves (i.e., three or five move problems). Although there is little evidence that directly links processing speed to problem solving performance, there may be indirect effects. For instance, it has been found that processing speed--both independently and concurrently with age--account for some of the variance in measures of fluid intelligence (Bugg et al., 2006). In general, more research will be needed to investigate the influence of processing speed on TOL performance.

Planning time. The time taken to develop an effective plan prior to engaging in a goal directed behavior(s) may influence one's ability to complete a task both effectively and efficiently. To efficiently solve problems on the TOL, the participant must plan a sequence of moves that will enable the goal state to be reached while using a minimal number of moves. Planning time, also known as initial think time (e.g., Asato et al., 2006), represents the time from when the participant is first exposed to the TOL problem to the time when the participant picks up the first bead. Most researchers use planning time as a dependent measure and investigate the extent to which other variables influence planning time (i.e., Kaller et al., 2008; Luciana et al., 2009). Only a few researchers have measured the amount of influence that planning time has on problem solving performance on the TOL (Asato et al., 2006; Phillips et al., 2001; Unterrainer et al., 2004). The results are both limited and mixed. For instance, Phillips et al. (2001) found no differences in performance between participants who were directed to plan their moves versus those who were not given directions to plan ahead.

This suggests that planning time doesn't necessarily predict TOL problem solving performance. It is necessary to note that all of the peg heights were the same length and five disks were used as opposed to the three balls used in many other studies. This may have affected the difficulty of the task and in turn, the results obtained by these researchers.

Subsequent studies, however, were able to successfully link planning time to problem solving performance. For instance, Unterrainer et al. (2004) found that the good performers on problem solving tasks spent twice as much time on preplanning time compared to intermediate and poor performers. Asato et al. (2006) examined participants between the ages of 8 and 30 and found that plan time increases with age. In this study, planning time had a large impact on problem solving performance. For instance, children had the shortest planning time and they performed worse than the older age groups in the study.

These findings suggest that the relationship between planning time and TOL performance is complex and not fully understood. Past research has yielded evidence highlighting age differences in planning time and problem solving performance in children, adolescents, and adults. Unfortunately, the extent to which planning time and problem solving performance are related, for other age groups such as young adults, mid-aged adults, and older adults, has yet to be investigated in published reports. The norms contained in this manual contains planning time across the lifespan (from 5 to 90). Further, the output from your program will allow you to examine the role of planning time in any sample you might examine on TOL performance. The output from the current software will allow you to investigate the nature of this variable across age groups or any special population you might study and to clarify the extent to which plan time predicts problem solving performance.

Inhibition. Inhibition refers to one's ability to inhibit a prepotent, dominant, or automatic response (Miyake, Friedman, Emerson, Witzki, & Howeter, 2000). Solving TOL problems requires one to inhibit moving a bead onto its goal position when an indirect move is required for an optimal solution. That is, for some problems one must inhibit moving a bead into its goal position and rather, move it onto a different peg in order to

free up the other beads, in order to solve some problems optimally. The majority of the studies that have investigated the relationship between inhibition and TOL performance typically correlate the performance on the inhibition task to performance on the TOL. While the method used to investigate the relationship is similar in most studies, the findings have been mixed. Findings on the effect of inhibition when solving TOL problems is mixed with effect sizes ranging anywhere from no effect (Koppenol-Gonzalez et al., 2001; Pulos & Denzine, 2005), to a medium effect (Zook et al., 2004), or to a large effect (Luciana et al., 2009; Welsh et al., 1999). All of these studies, with the exception of Luciana et al. (2009) who used the Go-No-Go task to measure inhibition in children, used the Stroop test to measure inhibition in college students. The sample size for most of these studies was low and the dependent variables of interest for both the Stroop test and the TOL differed across studies. This may explain the mixed findings in the literature regarding the relationship between inhibition and problem solving ability. There is an inadequate amount of research that investigates this relationship in children, adolescents, middle-aged adults, and older adults. Furthermore, the studies that investigated this relationship in the college population contain mixed findings. The literature would greatly benefit from future studies that investigate this relationship in each of the aforementioned age groups.

Working memory. Working memory involves the processes used to temporarily store and manipulate information in the midst of distraction and processing (Jaeggi, Buschkuhl, Perrig, & Meier, 2010). Miyake et al. (2000) highlighted the importance of a particular type of working memory known as updating. This requires one to code and monitor information required for a particular task and to alter any existing information held in working memory by replacing old, irrelevant information with more relevant information that is required for task completion. Thus, when completing TOL problems, participants execute a plan by cognitively ~~%~~keeping track+of any subsequent move in the sequence that needs to be made while discarding any of the other steps that had pertained to previous moves. Miyake suggested that the role of the updating function increases as task difficulty increases in a problem solving task such as the Tower of Hanoi (TOH). Although findings suggest that the TOH and the TOL are not identical problem solving tasks (Humes, Welsh, Retlaff, & Cookson, 1997), both require the

participant to cognitively formulate a plan and to successfully carry it out in order to increase the likelihood of solving the problem optimally. Thus, it is reasonable to suspect an updating role for working memory in solving TOL problems.

Research on the effect size of working memory on problem solving performance ranges anywhere from non-existent (Pulos & Denzine, 2005; Zook et al., 2004) to medium (Asato et al., 2006; Koppenol-Gonzalez et al., 2010) to large (Luciana et al., 2009; Unterrainer et al., 2004; Welsh et al., 1999). The mixed findings may be a product of the wide array of working memory tasks used. A major concern, however, is that the majority of the working memory tasks used did not contain an updating function. For instance, at least half of the studies that measure working memory use the digit-span task, a verbal working memory span task. In contrast, The TOL is a visuo-spatial task (Gilhooly et al., 2002) that most likely requires the constant update of working memory in order to keep track of the necessary components of the plan while releasing information that is no longer pertinent (i.e., the steps of the plan that have already been executed, thus an updating rather than span working memory task) to the plan in order to solve problems optimally.

The mixed findings in the literature suggest that the extent of the relationship between working memory and problem solving is unclear. Furthermore, the vast majority of the participants used in these studies were college age students. Although it would be beneficial to clarify the mixed findings in the literature by using participants from the college population, future research should also investigate this relationship using different age groups (i.e. children, middle aged adults, and older adults). Furthermore, future research that seeks to investigate the effect of working memory on TOL performance should consider using a visuospatial working memory task that contains an updating function, thus, replicating the nature of the working memory component that is required to solve TOL problems.

Shifting. Shifting refers to the ability to shift back and forth between tasks and mental sets (Miyake et al., 2000). The literature on shifting ability and its relation to problem solving performance on the TOL contains mixed findings. For instance, a lifespan study found a linear, inverse relationship between performance on a shifting task and problem

solving ability (Bugg et al., 2006). In other words, better performance on the shifting task was related to fewer excess moves on the TOL task (which demonstrates better performance). Furthermore, these researchers found age related declines with shifting. Given the relationship between shifting and problem solving ability, it follows that shifting ability and problem-solving performance would also decline with age. Although the findings from this study were able to link shifting ability to problem solving performance, other studies were unable to find a relationship between these variables (Pulos & Denzine, 2005; Zook et al., 2004). It should be noted that different assessments were used to measure one's shifting ability. For instance, some researchers used Part B of the Trails Making Test (Pulos & Denzine, 2005) while others used the Wisconsin Card Sorting Task (WCST; Bugg et al., 2006; Zook et al., 2004) in order to measure shifting ability. Although the use of different assessments may account for some of the discrepant findings, shifting ability and its relationship to TOL performance remains unclear.

Limitations of the Previous Research

Although many researchers have studied the effect of the above factors on TOL performance, there is still a lack of general consensus regarding the extent to which these factors influence performance. There are a few possible explanations for this. One explanation involves the statistical analyses used. Most studies used correlation or an analysis of variance (ANOVA) to measure the extent to which these factors influence TOL performance. Research has demonstrated that some of these intrapersonal factors are related and even interact to influence TOL performance. Thus, the effect sizes obtained for each factor when using these two particular statistical analyses may be misleading due to the possibility that the effect size obtained for each factor will likely represent a combination of both unique and shared variance which would provide an inaccurate representation of the extent to which each factor independently influences TOL performance.

The sample used may also contribute to the large range of effect sizes obtained for each factor. For instance, some studies investigated multiple factors despite having a small sample size (e.g., Pulos & Denzine, 2005). The sample itself may also account

for some of the discrepancies between the findings in the literature. While there are a few studies that include middle aged and older adults, the majority of the samples used tend to consist of children and young adults from the college population. The age of the participants needs to be strongly considered because children and adolescents' mental abilities have not fully developed. Thus, findings on the relationship between intrapersonal variables and TOL performance from studies that contain young children and college freshmen will only be representative of these variables during the time of their development. To gain a better, general perspective of how these variables influence TOL performance, it will be necessary to include participants of all ages.

Researchers' definition of problem solving performance represents another possible explanation that may account for differences in the effect sizes. Many studies measure problem solving ability based on the number of excess moves made. That is, the number of moves above the minimum number of moves needed to solve the problem (Phillips, Wynn, Gilhooly, Sala & Logie, 1999; Salthouse & Davis, 2006). Other studies, use the weighted performance score- the summed number of moves for correctly solved problems (Unterrainer et al., 2004)- and the total number of correctly solved TOL problems (Shallice, 1982; Albert & Steinberg, 2011) as the dependent variables.

Lastly, structural parameters of the TOL problems have been shown to influence problem solving performance. Previous researchers have demonstrated that manipulating the parametric properties of the TOL problem such as the minimum number of moves necessary to solve the problem, the number of indirect moves per problem, the position of the beads in both the start and goal states (the start and goal hierarchies, respectively), can influence the difficulty level of each problem (Berg et al. 2010; Kaller et al, 2004; Kaller et al. 2011). Until recently, the influence of these parametric properties went unrecognized by researchers. Thus, the versions of the TOL that were used in previous studies did not account for these parameters. Consequently, the difficulty level of the problems and overall performance varied. This likely explains the wide range of results obtained from the previous studies which aimed to measure the effect of intrapersonal variables on TOL performance.

In sum, the literature suggests that problem solving ability, when measured by one's performance on the TOL, may be influenced by several factors such as age, planning time, speed of processing, executive functions, fluid intelligence, and various combinations of these variables. The extent to which these intrapersonal variables independently influence performance on the TOL is unclear due to the different statistical methods used, the age range of the populations, and the different TOL versions used. More research addressing these issues will be necessary to improve researchers' understanding of which intrapersonal variables, and the extent to which they influence problem solving performance.

Data Management

All SANZEN Neuropsychological Assessment Tests share a single Participant Database. Whether you are using only one of our tests or all of them, all participant information and test results are stored in a single database file called the %Participant Database.+ This approach greatly facilitates the management of participant information as well as security of the data. To assure the privacy of each participant, access to this database is usercode/password protected.

In order to personalize access to and control over this database, a user must create and set up a Participant Database administrator. Therefore, if a user starts to run a test and generate data before setting up an administrator for the Database, the user will be prompted to read this section of the manual before proceeding further.

Participant Database Set-up

Setting up one's own administration of the SANZEN Participant Database requires only a few simple steps but, since this process both determines access and insures the security of the database, the process is important and, as such, is highlighted in red below.

PLEASE NOTE: Since all SANZEN tests share the same Participant Database, if you have previously installed any other SANZEN test(s) then setup of the Participant

Database was already done in that previous Sanzen test installation and this step can be skipped.

If, however, this is the first installation of a SANZEN Neuropsychological Test then a unique participant database administrator will need to be set up. The test comes programmed with a single generic database administrator already assigned a pre-programmed USER NAME, USER CODE, and PASSWORD. The pre-programmed User Name is %Sanzen Administrator,+the User Code is the word %admin,+and the Password is %sanzen.+ For database security, we recommend that the user create a new Database Administrator and then, when that has been successfully accomplished, that the generic, pre-programmed Sanzen Administrator be deleted. The following steps will guide you through this process.

From the test's **WELCOME** screen (Figure 1), login to the **PARTICIPANT DATA MANAGEMENT** window by clicking the **Participant Database** button to the right of the screen. This will result in the display of the **LOGIN** window shown below in Figure 2.

The image shows a Windows-style dialog box titled "Tower of London (Login)". Inside the dialog, there are two text input fields. The first is labeled "User Code:" and the second is labeled "Password:". Below these fields, a message states "User Code and Password are case sensitive." At the bottom of the dialog, there are two buttons: a green "OK" button on the left and a pink "Cancel" button on the right.

Figure 2

In the **User Code** box type in the word %admin+and in the **Password** box type the word %sanzen+(no quotation marks). Both user codes and passwords are case sensitive so be sure to use lower-case. Now press the **OK** button.

Pressing the **OK** button will result in the display of the **PARTICIPANT DATA MANAGEMENT** window shown in Figure 3, below. (Note: Your system will not be displaying the descriptive information for John Doe.)

Tower of London (Participant Data)

11

Participant Id

jones, john

Add New Participant

Delete Participant

Output to Text File

Backup Participants

Administer Passwords

Participant Information

john

MI

jones

First Name

MI

Last Name

10439 W. 49th Avnue

Street Address

Monroe City

MI

87493

639-3284

City

State

Zip Code

Telephone

49

18

Masters

2/10/2012 4:57:48 PM

Date of Birth (mm/dd/yy)

Age

Education (Years)

Education Level

Entry Date

make

right

2/10/2012 4:57:48 PM

Gender

Ethnicity

Handedness

Last Update

Fields labeled in red must be entered.

Update

Tests Taken

Tower of London, Shallice1982 - 2/10/2012 5:03:28 PM

Exit

Figure 3

On the **PARTICIPANT DATA MANAGEMENT** window click the **Administer Passwords** button to open the **ADMINISTER USERCODES/PASSWORD** window shown below in **Figure 4**.

Tower of London (Administer Usercodes/Passwords)

User Id Number

Select User

Add New User

Delete User

User Name

User Code

Password

Access Privileges

☐ Administrator (All)

☐ Data Administrator

☒ Data Entry Only

Update

Exit

Figure 4

You are going to create a new administrator. First, click the **Add New User** button. Now enter a **User Name** that can identify this user from others. Then enter a unique login **User Code** and **Password** for this user. Under the **Access Privileges** box, be sure to give this user **Administrator (All)** privileges as only users with this level of privilege can get access to this screen to create new or delete existing users. (User privileges will be explained in more detail below). Click the **Update** button and then **Exit** the **ADMINISTER USERCODES/PASSWORD** window.

Return to the **WELCOME** screen and click on the **Participant Database** button. Now attempt to login to the database administration system using the User Code/Password you have just created. This should allow you access to the **PARTICIPANT DATA MANAGEMENT** window. From that screen, again click the **Administer Passwords** button to insure that you can get to the **ADMINISTER USERCODE/PASSWORD** window using your new code.

Once you have ascertained that your new login information will allow you access to the **ADMINISTER USERCODES/PASSWORD** window, it is then safe to delete the preprogrammed Sanzen administrator. In the **ADMINISTER USERCODES/PASSWORD** window, select **Sanzen Administrator** from the **Select User** pull down list and click the **Delete User** button to delete the pre-assigned Sanzen Administrator.

A word of warning: only users with Administrator (All) privileges can create new users, so don't lose this usercode/password. You can, of course, consistent with your own security policy, create as many Administrator (All) accounts as you wish. See the section on User Privileges below for a discussion of the access rights of the other two levels of security.

User Privileges

From the **ADMINISTER USERCODE/PASSWORDS** window (accessed, as described above, via the **PARTICIPANT DATA MANAGEMENT** window) an administrative user

can create new users and determine their level of access to the system. A user can be assigned any one of three levels of access.

At the lowest level, **Data Entry Only**, the user can only enter information for a new participant. They cannot print, edit or even view other participant records. This is a level likely to be assigned to an individual whose only responsibility is to test participants.

At the **Data Administrator** level, the user can enter new participant information, view and edit all participant records, delete a participant, and print participant records.

Users with **Administrator (All)** privileges can do all that a Data Administrator can do but can also add new users to the database security system.

Adding New or Editing Existing Participants

From the **PARTICIPANT DATA MANAGEMENT** window (Figure 3, above), add a new participant by first clicking the **Add New Participant** button. The Participant Information frame will be cleared and the cursor will be positioned in the first field **First Name**. At a minimum, a first and last name must be entered in order to register a Participant. After entering the relevant information, click the **Update** button and the new Participant will be added to the Participant Database.

Alternatively, an existing Participant's information can be displayed and/or edited by selecting a Participant from the pull down list located immediately above the **Add New Participant** button. The Participant's current information and a list of the tests they have taken will be displayed. Of course, all of this can be done only by a user who has **Data Administrator** or **Administrator** privileges.

Text Output

Participant data cannot be printed directly from the data management system, however, clicking the **Output to Text File** button (on the **PARTICIPANT DATA MANAGEMENT**

window, Figure 3) allows the user to write to a file, selected information in formats compatible either with popular word processors, spreadsheets or statistical packages.

Figure 5 (below) shows the window for selecting and formatting the text file.

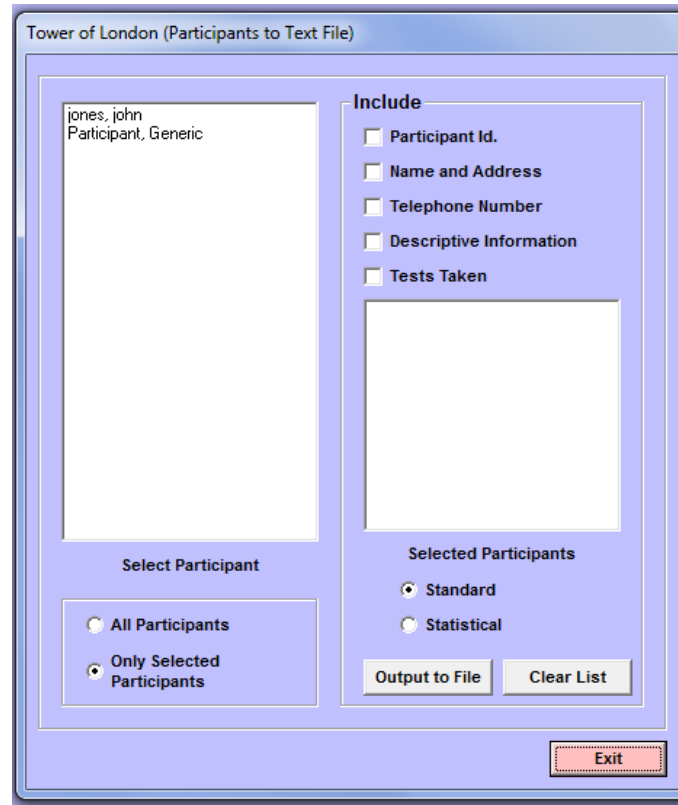


Figure 5

The %Select Participant+box on the left side of the screen automatically and alphabetically lists all participants currently in the system. A scroll bar will appear to the right of this list if there are more participants than can be accommodated in the visible area. Directly beneath this list, the user can choose to send to the text file either the entire list of Participants or only a selected subset by %checking+ either **All Participants** or **Only Selected Participants**.

If the %**Only Selected Participants**+option is chosen, clicking on the name of each selected participant in the left hand Participant list will cause that name to appear in the %Selected Participants+list on the right side of the screen.

Double-clicking on a participant's name in the "Selected Participant" list will remove that name from the list.

Once the list of selected participants has been generated then the data items to be included in the list (Participant ID, Name and Address, etc.) can be selected by checking the appropriate boxes.

Finally, the user can specify whether the data is to be formatted in either a standard multiline text format suitable for either a text editor or a spreadsheet, or as a single line (one for each participant selected) comma delimited format suitable for being read by popular statistical packages. Clicking the **Output to File** button will show a standard save file dialog box.

Backup Participant File

It is important that from time-to-time a backup copy of the Participants database be made. Loss of data can, at the very least, be frustrating and though today's computers and disk drives are very reliable, they do still sometimes fail. Clicking the **Backup Participant File** produces a save file dialog allowing a copy of the Participants Database to be made. This copy should be made to some external storage device such as an external (usb) disk drive or to a thumb drive.

Executing a Tower of London Test

On the **WELCOME** screen (see Figure 1), select a test from the pull down "Select a Test" list and then click the **Execute Tower of London** button. This will produce the **SELECT A PARTICIPANT** window (Figure 6). Select a participant from the "Select a Participant" pull down list. This assumes that the participant has already been added to the Participant Database; if the participant has not yet been added, then before proceeding you will need to return to the **WELCOME** screen (by clicking the **Cancel** button) and add the participant to the database (see the section on adding new participants). Once a participant has been selected there is an option to then enter the tester's name; if entered, the name of the person administering the test will be added to

the participant's test record. After selecting the participant and, optionally, adding the tester's name, click the **Run Test** button.

Figure 6

The SANZEN Tower of London Test comes with two pre-programmed tests: a computerized version of Shallice's 1982 original test and SANZEN Neuropsychological Assessment Test's Normed-London test.

Figure 7 (below) shows the first screen for SANZEN Neuropsychological Assessment Test's Tower of London Normed-London test. The first trial of all Tower of London tests is always assumed to be a practice trial and, as such, the instructions for taking the test are displayed at the bottom of the screen. In subsequent trials the instructions are suppressed.

Depending on how the test has been set up, participants can respond via touch screen or mouse, the latter offering either a point and click or slide bar option. (1) If a **touch screen** is used, the participant can touch the bead, base, or peg area of the bead to be moved. (2) **Using the mouse**, the participant can left click either on the bead to be moved, the base area under the peg holding the bead to be moved, or on the area immediately surrounding the peg holding the bead to be moved. (3) Finally, **using the slide-bar** option, as in the Normed-London test displayed in Figure 7, (in which the mouse pointer has been captured by the slide-bar under the **Work Space**), the

participant can simply move the slider to a position under the peg containing the bead to be moved and then click the left mouse button.

We have included the slide-bar response input for two reasons. First, an earlier version of this test used only slide-bar input, and that is the version that was used in collecting the normative data included with your SANZEN Tower of London Test. Second, there is anecdotal evidence that the slide-bar is more easily used by senior participants.

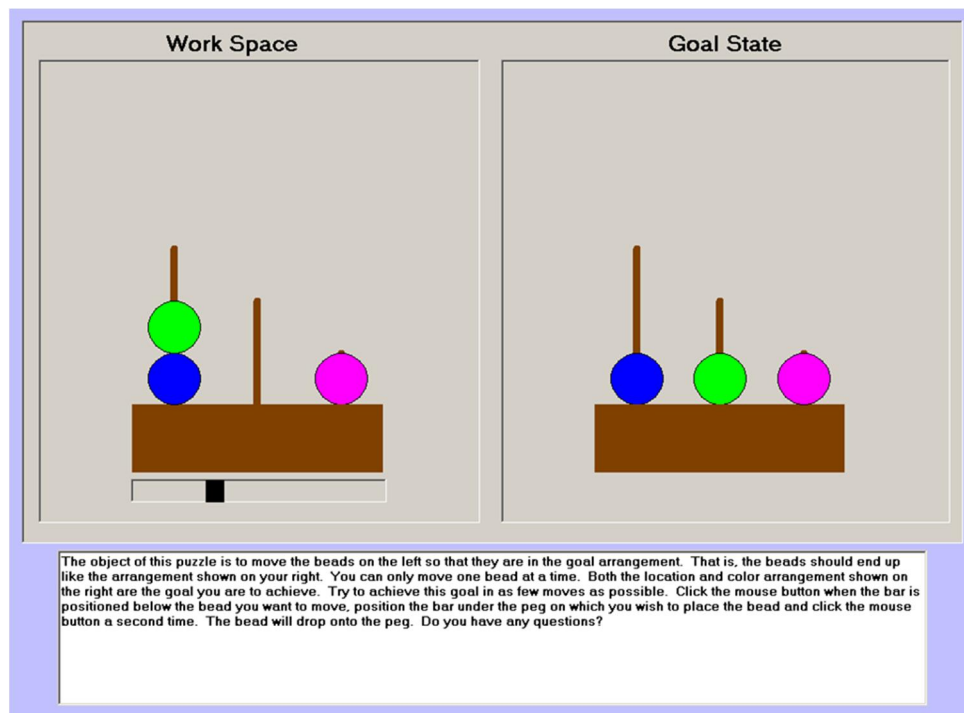


Figure 7

Depending on how the test has been setup, the participant may be given certain feedback messages after each trial. (Note: Feedback messages will be explained in more detail under the section below on how to %Create/Edit a Tower of London test+). At the end of the test the participant will be thanked for their participation and control will be returned to the **WELCOME** screen.

As with all SANZEN tests, the Tower of London test can be terminated at any time by pressing Ctrl x. On initiating this sequence the user will be asked to confirm the choice

to terminate the test; if the choice to terminate is affirmed, the test will be terminated and no data from the test will be saved.

Analysis of Results

Clicking the **Analysis** button on the **WELCOME** screen (Figure 1) will produce the **ANALYSIS** window (Figure 8, below).

Participant Name: john jones
Address: 10439 W. 49th Avenue
Monroe City, MI 87493
Telephone Number: 639-3284
Date of Birth:
Age: 49
Education: 18
Education Level: Masters
Gender: male
Ethnicity:
Handedness: right

Trial	Towers	Minimum Moves	Participant Moves	Participant Excess Moves	Participant Drop Errors	Time to First Move (Secs.)	Total Time to pickup (Secs.)	Total Trial Time (Secs.)
1>	3	2	2	0	0	2.902	4.899	6.755
2	3	2	2	0	0	1.373	2.965	4.415
3	3	2	3	1	0	2.589	4.992	8.751
4	3	3	3	0	0	2.356	7.145	9.142
5	3	3	3	0	0	1.95	3.682	6.037
6	3	4	4	0	0	6.396	10.342	13.041
7	3	4	4	0	0	3.759	7.473	10.639
8	3	4	5	1	0	2.542	5.898	12.23
9	3	4	4	0	0	9.641	17.253	31.84
10	3	5	5	0	0	9.204	15.272	37.534
11	3	5	6	1	0	10.374	14.087	18.829
12	3	5	5	0	0	4.602	9.251	12.589
13	3	5	5	0	0	12.184	16.786	20.374
Totals			51	3	0	69.872	120.045	192.176

Event Id	Event	Argument	Time Stamp
1	Trial	1	1139072
2	PegCnt	3	1139072
3	MinMoves	2	1139072
4	Start Trial	1	1139072
5	BeadUp	35	1141974
6	BeadOn	15	1143003
7	BeadUp	33	1145000
8	BeadOn	23	1145733
9	Moves	2	1145827
10	End Trial	1	1145827
11	Trial	2	1155842
12	PegCnt	3	1155842
13	MinMoves	2	1155842
14	Start Trial	2	1155842
15	BeadUp	35	1157215
16	BeadOn	15	1158057
17	BeadUp	33	1158649
18	BeadOn	23	1160163
19	Moves	2	1160257
20	End Trial	2	1160257
21	Trial	3	1170257

Print
Export

Export to Clipboard

jones, john

11

ID

Get Participant Data

☒ Suppress identifying participant information.

Print

Playback

Shallce1982 -- 2/10/2012 5:03:28 PM

Tower of London Test(s) Taken. (Click on the test you wish to analyze.)

Exit Analysis

Trial terminated due to excessive moves.
* Trial terminated due to timeout.

Figure 8

To see a participant's data, select the participant's name from the **Get Participant Data** pull-down list. A list of all versions of the Tower of London Test the selected participant has taken will appear in the **Tower of London Test(s) Taken** box at the bottom right of the screen. Click on the specific test to be analyzed. A small box will open requesting the user to select the block of trials to be included in the summary analysis of the participant's test performance. This allows the user to exclude **practice** or **demonstration** trials from the test summary analysis (up to the first five trials can be excluded from the analysis). The selection of a starting trial will cause the analysis to

automatically display. The first trial used in the analysis is indicated by **%1** next to the trial number; in the analysis displayed in **Figure 8** the first trial included in the analysis was trial one.

Clicking the **Print** button will send a copy of the results to the printer along with the participant's unique identification number (assigned at the time the participant was added into the Participant Database); the test version name; the date and time the test was administered; the date and time the report was generated; and the name of the person administering the test (if it was entered).

Checking the **Suppress Participant Identification Information** box for the Participant(s) selected will suppress all personal identifying information and will include only the non-personal identifying information outlined in the paragraph above -- that is, the contents of the text box above the grid will not appear on the printout. This is useful when printed copies of the data may need to be kept in less secure environments or when the individual evaluating the data needs to be **%blind**.+ The linkage between suppressed participant information and test results can always be recovered by those having at least **%Data Administrator**+level access to the Participant Database, or by reprinting the analysis with the **%Suppress Participant Identification Information**+box unchecked.

Clicking the **Export to Clipboard** button will place a spreadsheet compatible copy of the summary table on the clipboard.

Clicking the **Playback** button produces the playback window shown below in Figure 9. This window allows for the **%playback**+of all moves made by the participant for the selected trial. Select a trial from the **%Select Trial**+pull down list, and then click the **Play** button. The moves made by the participant for the selected trial will be displayed in the **Work Space** area. The speed of playback can be controlled using the **Speed Control** slider.

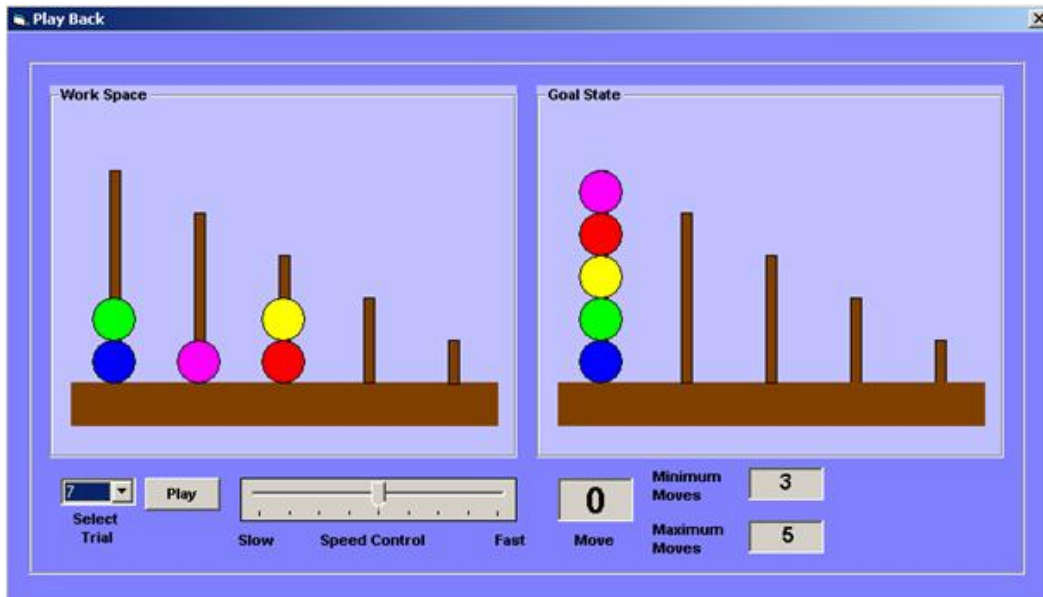


Figure 9

The grid located on the right side of the **ANALYSIS** window contains a real time+ record of the participant's performance for the analyzed test. This record is provided in case the test user wishes to perform an analysis not given by summary statistics. The grid provides information about all of the salient events that occurred during the test.

The first column is simply the event's ID, and reflects its occurrence position in the test. The second column displays the nature of the event. The third column contains an argument+qualifying the nature of the event. And the fourth column contains a timestamp+indicating to the nearest millisecond when the system detected the event.

For example, event 4 is %Start Trial+,an event occurring coincidentally with the display of the trial, and the argument %1+indicates that it is the start of trial 1. This event occurred 1,139,072 milliseconds after the last start time for the computer running the test. (The computer maintains a running clock indicating the time in milliseconds since it was last started.) Event 5 was a bead pickup response indicated by the event designation %BeadUp+and the argument %35+indicates that the bead in position 5 located on peg 3 was the one picked up. (**Figure 10**, below, shows the bead positions and peg numbers.) Event 6 was a %BeadDn+event, the argument 15 indicates that bead 5 was dropped on peg 1.

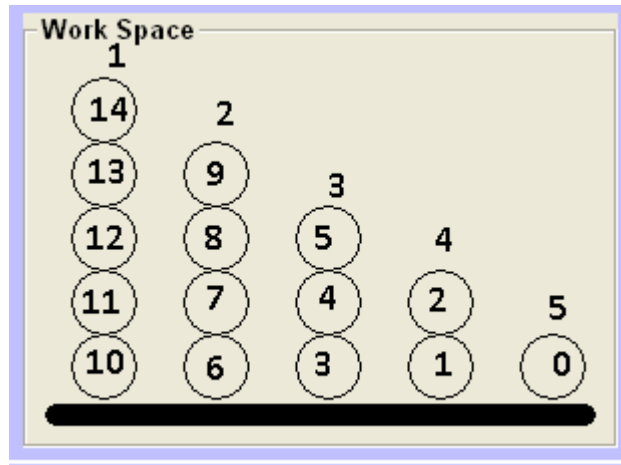


Figure 10

The contents of this grid can be printed by clicking the **Print** button. Alternatively, by clicking the **Export** button the grid's contents can be sent to the clipboard in a format that can be pasted into a spreadsheet.

Creating and Editing a Tower of London Test

Create a new or edit an existing Tower of London test by first clicking the **Create/Edit Tower of London** button on the **WELCOME** screen. This will produce a screen similar to the one shown below in Figure 11. The initial **CREATE / EDIT** screen will have none of the information filled in.

Create a New Test:

Before beginning the process of actually constructing a new Tower of London Test, it is helpful to first plan the test's features. In other words, it facilitates the creation process to first design the test before you attempt to construct it.

Create a new test by clicking the **Create New Test** button. The cursor will then be positioned in the Test Name text box. Type a unique name for the new test and, if needed, specify the name of the Test Author.

Before specific trials can be created and added to a new test definition, certain overall parameters for a test must first be decided and defined. These parameters include: **inter-trial interval; maximum trial time; maximum moves; and certain optional feedback messages.** Each of these will be discussed in turn below.

Inter-Trial Interval. This number will determine the amount of time (in seconds) that will elapse in a given test between the end of one trial and the beginning of the next.

Trial 1

Trial #	1
Peg Count	3
Minimum Moves	2
Work Space	
	3
	4
	5
Goal State	
	3
	1
	0

Work Space: [Diagram showing 3 colored beads (red, green, blue) on a bar]

Goal State: [Diagram showing 3 white beads on a bar]

Trial Count: 22, Peg Count: 3, Minimum Moves: 2

Color Palette: Add New Trial, Insert New Trial, Replace Current Trial, Delete Current Trial

Test Definition

Existing Tests: Normed-London (selected)

Create New Test, Save Current Test, Delete Current Test

Point and Click, Touch Screen, Slide Bar

Test Messages: Work Space, Work Space, Goal State, Goal State, Please Wait, Wait Message

You made [MC] moves. Your goal was [MM] moves.

You exceeded the maximum number of permissible moves.

You exceeded the maximum permissible Time.

Thank you for your participation.

Exit Setup

Figure 11

Maximum Trial Time: If a **Maximum Trial Time** other than 0 is specified then a trial which has not been completed within the specified time will be terminated. Leaving the **Maximum Trial Time** at 0 means a trial will not timeout. (Note: If a maximum trial time is set, then after the specified time has elapsed the trial will end and the %please wait+)

message of the inter-trial interval will be displayed. Alternatively, if the feedback box is checked, when the trial abruptly ends the participant will first receive a message explaining that the trial has timed out, and then the %please wait+message of the inter-trial interval will display.)

Maximum Moves: Setting **Maximum Moves** to a value other than 0 causes a trial to terminate if the number of moves made by the participant is equal to the specified Maximum Moves value and has not resulted in a solution to the problem. Setting the value to 0 means there is no maximum on the number of moves a participant may make in attempting to solve a trial's problem. (Note: If a maximum number of moves is set, then after the specified number of moves have been made by the participant the trial will end and the %please wait+message of the inter-trial interval will be displayed. Alternatively, if the feedback box is checked, when the trial abruptly ends the participant will first receive a message explaining that the number of permissible moves for that trial has been exceeded, and then the %please wait+message of the inter-trial interval will display.)

Messages: All of a test's messages can be changed to meet the language needs of the participant population or deleted altogether.

Some test messages are basic to a participant's understanding of the test, and as such, unless the text within the message box for that message is deleted and the box left blank, these messages will automatically be displayed to the participant.

Basic test messages include: Work Space; Goal State; a %Please Wait+message; and a %Test End+message. **Work Space** indicates the active window in which the participant will be working to solve the problem. **Goal State** indicates the static window in which the problem's specified goal will be displayed to the participant. The **Wait Message** is displayed on the screen (for the number of seconds specified in the Inter-trial interval box) to participants between trials, and the **Test End Message** is displayed to the participant at the conclusion of the test.

Feedback Messages: Unlike the basic test messages described above, Feedback Messages are optional and are only made active by checking the **Feedback** box.

Checking this option when defining a test causes the test to provide participants feedback after each trial. Feedback Message options include: a **%performance+option** which reports the minimum number of moves required to solve the problem and the number of moves the participant made in solving the problem; a **%timeout+message** which displays if the participant exceeds a set maximum time; and an **%exceeded maximum moves+message** if the participant exceeds a set number of maximum moves.

The **performance feedback** message contains two special tokens [MC] and [MM] which must appear in the message irrespective of other changes that may be made to the message's composition. At the time that feedback is given to the participant, [MC] is replaced by the actual **Move Count** of the participant on the trial and [MM] is replaced by the **Minimum number of Moves** required for the problem's solution.

Feedback messages for trial termination due to either exceeding the Maximum Moves value or the timeout value can also be tailored to meet the tester's need. Even if the **Feedback** box has been checked, these messages will only be displayed if a maximum number of moves and/or a maximum trial time have been designated (as described above under paragraphs entitled **%Maximum trial Time+** and **%Maximum Moves+**).

Use Demo Trial: If the **Use Demo trial** box is checked, then the first trial of a test is initiated by the participant or tester solving the problem shown above the instruction window; otherwise, if the box is unchecked, the first trial is initiated by the participant either clicking or touching the instruction window.

Response Modality: Toward the bottom left of the Create/Edit screen, three response options are provided -- **Point and Click, Touch Screen, and Slide Bar**. Select a response modality to be part of a test's definition by checking the box next to it. The preferred response modality for any given test can be changed at any time; to do this, from the **CREATE/EDIT** screen, select the test from the **%existing tests+** drop-down menu, then check the preferred response option, then click **%Save Current Test.**

Selecting the **Point and Click** option requires the participant to point (with the mouse pointer) to either the bead they wish to move, the **%peg+** on which it resides, or the base immediately under the peg -- and then to click the left mouse button. The peg on which

the bead is to be deposited is similarly selected by pointing (with the mouse pointer) at the targeted peg and clicking the left mouse button. Note: Even when the %point and click+option has been selected for a given test, if a touch screen computer is being used, the touch screen option will still be active.

The **Touch Screen** option is identical to the Point and Click option except that the participant will use their finger to touch the bead they wish to move and then the peg on which it is to be deposited. NOTE: When the touch screen option is selected, the mouse cursor will be hidden but the mouse, if available, will still be operational; therefore, if the touch screen modality is to be used, the mouse should not be available to the participant.

The **Slider** option %captures+the cursor in a slide bar located directly under the base of the Working Area display. The cursor (a black square) can be moved left or right by moving the mouse left or right. A bead is selected for moving by positioning the cursor under the peg holding the bead and clicking the left mouse button. The peg on which the bead is to be deposited is selected by positioning the cursor under the selected peg and clicking the left mouse button. This option is particularly useful when working with participants with motor control problems who may have difficulty positioning either the mouse pointer or their finger with the precision necessary to accomplish the test.

Instructions: The test creator has two options for creating a new instruction. An instruction file that was created at an earlier time can be imported using the **Load Text From File** capability, or the new instruction can be typed directly into the edit field of the **Instruction Editor**. The %load text from file+approach is preferred when the same or a similar instruction is going to be used for a number of different tests, or when the instructionsqtext format is particularly complex. If an external text editor is used, it must be capable of saving the file in Richtext (rtf) format.

Adding Trials

Once the overall parameters for a test have been defined, then specific trials for that test can be created and added to the test definition. To add a trial (or a number of

trials) to a test, first select the appropriate test by highlighting it in the %Existing Tests+ drop-down list.

In creating a trial for a test, the user initiates the trial creation process and simultaneously determines a new trial's order by selecting one of the following buttons: Add New Trial; Insert New Trial; Replace Current Trial; or Delete Current Trial. The **Add New Trial** button adds a new trial to the end of a selected test's existing trails. If there are currently no defined trails within a test, clicking Add New Trial will create Trial number one. The **Insert New Trial** button inserts a new trial immediately before the currently displayed trial, thus changing each subsequent trial's number. The **Replace Current Trial** button clears the currently displayed trial's definition and allows for a new definition of that trial. The **Delete Current Trial** button completely deletes the currently displayed trial from the selected test. Each of these will be explained in more detail below.

Adding a new Trial: Clicking the **Add New Trial** button adds a new trial to the end of the test. That is, if a current test already has 6 trials, then clicking the **Add New Trial** button will add a 7th trial at the end of the existing six trials.

Clicking the **Add New Trial** button causes the cursor to be positioned in the **Peg Count** text box. Enter a number between 3 and 5 to specify the number of pegs (or towers) this trial will have. Entering a number here will cause that number of pegs to display in the Work Space window.

The cursor will then move to the **Minimum Moves** text box where the minimum number of moves required to solve the problem must be entered before the trial can be created. This number is used both for test results analysis and, (if the feedback box is checked), for participant feedback, and therefore should be carefully calculated based on the test author's intended trial design. Please note: the system will not correct an erroneous entry here, so it is the test designer's responsibility to insure that the %minimum moves+ entered at the time of a trial's creation correctly describes the trial design.

Specifying the %minimum moves+ will cause the display of the appropriate number of beads and pegs to be displayed in the **Work Space** window and a %color palette+ of five

colors to be displayed below that window. Define the work space by first clicking on one of the color swatches and then clicking the bead in the work space area that is to have that color. Continue doing this, selecting a new color each time, until the appropriate number of beads has been colored (e.g., three beads for a three tower problem, five beads for a five tower problem). If a mistake is made in selecting/coloring a bead, right click the improperly selected bead to de-select it, then left click the correct bead to select/color it.

Completing the definition of the work space automatically results in the appropriate display of pegs and beads in the **Goal State** window. Use the same process to populate the goal state window as was used to place beads in the work space.

Once the Goal Space has been defined, a message will appear on the screen stating that the trial definition has been successfully completed. If no more trials are going to be added to the test, then click **Ok** on the displayed message to collapse it, and then click **Save Current Test** to save the newly added trial to the test definition.

If, on the other hand, more trials are going to be added to the same test, then click **Ok** on the displayed message to collapse it, and then click the Add New Trial button, and repeat the process described above. Repeat this process to add as many trials as desired to the selected test, and then, when finished and before exiting, click **Save Current Test** to save all the newly added trials to the test definition.

If a test or trial has been changed and the user attempts to exit without saving, a message will be displayed warning the user that changes have been made that have not yet been saved, and asking the user to confirm the command to EXIT without saving the new changes.

Inserting a New Trial: Clicking the **Insert New Trial** button inserts a new trial immediately before the currently displayed trial, thus changing each subsequent trial's number. For example, if the Insert New Trial button is clicked while a test's 3rd trial is displayed, then the newly inserted trial would displace the current trial number to become the new trial # 3, and the trial that had been trial # 3 would become trial # 4.

The process for creating the inserted trial is identical to the one described (above) for adding a new trial.

Replacing the Current Trial: Clicking the **Replace Current Trial** button clears the currently displayed trial's definition and allows for a new definition of that trial. The process for creating that new trial is identical to the one described (above) for adding a new trial.

Delete Current Trial: Clicking the **Delete Current Trial** button completely deletes the selected trial from a test, thus changing the numerical order of any other subsequent trials within that test. For example, in a test with four trials, if trial #3 is deleted, then trial #4 would become the new trial #3, and after the deletion the test would now have a total of three trials.

Design Grid: To the left of the **Work Space** window is a grid that contains the actual data used by the Tower of London Test to construct each trial. The trial number is displayed on the first line; the next line specifies the number of pegs (towers) the problem uses; and the third line specifies the minimum number of moves required to solve the problem.

Each bead is identified by a number from 0 to 14, starting with the 0-bead on the right-most peg, proceeding to the 1-bead (the bottom bead of the two bead peg), and the 2-bead (the top bead of the two bead peg), continuing to the 14-bead (the top bead of the five bead peg). In the example shown in Figure 9, the blue bead is in the 3 position for both the **Work Space** and the **Goal State** while the magenta bead is in the five position in the **Work Space** but in the 0 position in the **Goal State**.

Navigation Buttons: Immediately below this grid are four buttons <<, <, >, >> that allow navigation among the defined trials.

Editing an Existing Test:

On the **CREATE/EDIT** screen, select a test to be edited from the %Existing Tests+pull down list. The process from this point on is identical to the one described for creating a new test (See **Create A New Test** above).

A selected test can be edited in several ways. The parameters of the test can be edited, and individually selected trials within a test can be edited.

A previously defined trial can be edited in specific details related to that trial (e.g., instructions, maximum trial time, maximum moves, etc); however, the design set-up of the trial (the number of beads, number of pegs, and minimum moves) cannot be changed once it has been defined. Instead, in order to change any of these basic set-up features of a specific trial's design, it is necessary to use the Replace Current Trial button, and start from scratch in designing the trial.

Save Current Test: The Save Current Test button is used to save added or changed features to a given test (and, as described above in %Adding New Trials, it is also used to save additions/changes made to trials within a test). Once a test has been created or edited, the **Save Current Test** button must be clicked in order to save any additions or changes to the test's parameters. If a user makes changes to a test and attempts to exit without first clicking the Save Current Test button, a warning message pops up asking the user to confirm the wish to exit without saving the changes to the test.

Delete Current Test: A test can be deleted by first selecting it from the %Existing Tests+list, then clicking the **Delete Current Test** button.

Normative Data

Participants were recruited from a college student population, relatives of students, or from a local senior center. Participants under 18 years of age received five dollars per hour and participants over 60 years of age received 10 dollars per hour. Participants between the ages of 18 and 59 received extra course credit for their participation.

Participants reported no head injuries, neurological diseases, or psychiatric illnesses that they believe would affect their performance.

Demographics

Topic and Age Group		Mean	Standard Deviation	Standard Error	Sexes Male:Female (same for all variables)
Age Group	5 to 9	7.13	1.36	.08	135:173
	10 to 14	11.95	1.45	.09	145:144
	15 to 19	17.9	1.26	.05	181:412
	20s	22.77	2.74	.11	185:487
	30s	33.88	2.89	.21	56:140
	40s	44.39	3.07	.23	39:142
	50s	53.86	2.71	.22	36:119
	60s	64.27	2.8	.2	56:143
	70s	74.55	2.83	.18	74:164
	80s	83.25	2.67	.24	43:79
Years of Education	5 to 9	1.91	1.34	.08	
	10 to 14	6.48	1.64	1.0	
	15 to 19	12.57	1.42	.06	
	20s	14.72	1.16	.05	
	30s	15.14	1.57	.11	
	40s	14.92	1.9	.14	
	50s	15.45	2.11	.17	
	60s	15.16	2.15	.15	
	70s	14.69	2.57	.17	
	80s	14.6	2.41	.22	
WASI Verbal IQ	5 to 9	119	15	2	
	10 to 14	124	15	2	
	15 to 19	114	13	1	
	20s	114	13	1	
	30s	114	13	2	
	40s	119	10	1	
	50s	122	11	1	
	60s	118	13	1	
	70s	121	13	1	
	80s	121	16	2	
WASI Performance IQ	5 to 9	111	20	2	
	10 to 14	112	13	1	
	15 to 19	109	11	1	
	20s	111	11	1	
	30s	115	14	2	

40s	115	10	1	
50s	116	10	1	
60s	113	14	1	
70s	120	16	1	
80s	120	17	2	
WASI Full IQ 5 to 9	118	14	1	
10 to 14	119	13	1	
15 to 19	110	14	1	
20s	112	11	1	
30s	116	12	1	
40s	118	10	1	
50s	121	10	1	
60s	118	13	1	
70s	123	15	1	
80s	123	16	2	
WASI Matrix Raw Score 5 to 9	18.44	6.82	.62	
10 to 14	27.51	3.92	.35	
15 to 19	29.11	3.75	.28	
20s	29.08	3.17	.21	
30s	29.47	3.33	.39	
40s	28.98	3.7	.4	
50s	27.43	3.24	.34	
60s	25.02	5.15	.46	
70s	24.11	6.9	.53	
80s	19.16	6.74	.71	

Tower of London Excess Moves across 21 Trials for 10 Age Groups

Tower of London Performance by 5-9 Year Olds (N = 300)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.397	.160	.082	.711
2	.380	.043	.296	.464
3	1.140	.094	.955	1.325
4	1.640	.077	1.489	1.791
5	1.637	.085	1.470	1.803
6	.967	.072	.825	1.108
7	1.017	.110	.800	1.233
8	.917	.044	.831	1.003
9	2.853	.101	2.655	3.052
10	1.507	.137	1.237	1.776
11	1.713	.094	1.529	1.898
12	.940	.052	.838	1.042
13	.590	.031	.529	.651
14	2.120	.115	1.894	2.346
15	3.607	.110	3.390	3.823
16	8.887	.401	8.100	9.674
17	2.387	.080	2.231	2.543
18	1.790	.075	1.642	1.938
19	4.493	.227	4.049	4.938
20	2.897	.102	2.696	3.097
21	1.330	.073	1.187	1.473

Tower of London Performance by 10-14 Year Olds (N = 283)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.085	.165	-.239	.409
2	.021	.044	-.066	.108
3	.353	.097	.163	.543
4	.420	.080	.265	.576
5	.654	.088	.482	.825
6	.127	.074	-.018	.273
7	.343	.114	.120	.565
8	.226	.045	.138	.315
9	1.300	.104	1.096	1.505
10	.558	.141	.281	.835
11	.908	.097	.718	1.098
12	.191	.054	.086	.296
13	.191	.032	.128	.254
14	1.180	.119	.947	1.413
15	1.159	.114	.936	1.382
16	3.841	.413	3.031	4.651
17	1.021	.082	.861	1.182
18	.336	.078	.184	.488
19	2.675	.234	2.217	3.133
20	1.035	.105	.829	1.242
21	.548	.075	.400	.695

Tower of London Performance by 15-19 Year Olds (N = 568)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.058	.117	-.171	.287
2	.040	.031	-.021	.102
3	.273	.068	.139	.407
4	.208	.056	.098	.318
5	.454	.062	.333	.575
6	.079	.052	-.023	.182
7	.343	.080	.186	.500
8	.086	.032	.024	.149
9	.741	.074	.597	.886
10	.285	.100	.090	.481
11	.352	.068	.218	.486
12	.083	.038	.009	.157
13	.044	.023	.000	.088
14	.688	.084	.524	.853
15	.588	.080	.431	.745
16	2.125	.292	1.553	2.697
17	.460	.058	.346	.573
18	.215	.055	.107	.322
19	1.708	.165	1.385	2.031
20	.491	.074	.346	.637
21	.315	.053	.211	.419

Tower of London Performance by 20-29 Year Olds (N = 625)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.037	.111	-.181	.255
2	.019	.030	-.039	.078
3	.282	.065	.154	.410
4	.179	.053	.074	.284
5	.318	.059	.203	.434
6	.086	.050	-.011	.184
7	.280	.076	.130	.430
8	.080	.030	.020	.140
9	.480	.070	.342	.618
10	.331	.095	.145	.518
11	.314	.065	.186	.441
12	.061	.036	-.010	.132
13	.022	.022	-.020	.065
14	.350	.080	.194	.507
15	.384	.077	.234	.534
16	2.426	.278	1.880	2.971
17	.432	.055	.324	.540
18	.142	.052	.040	.245
19	1.696	.157	1.388	2.004
20	.482	.071	.343	.620
21	.122	.051	.022	.221

Tower of London Performance by 30-39 Year Olds (N = 184)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.136	.205	-.266	.538
2	.049	.055	-.059	.157
3	.174	.120	-.062	.410
4	.261	.099	.068	.454
5	.489	.109	.276	.702
6	.033	.092	-.148	.213
7	.185	.141	-.091	.461
8	.060	.056	-.050	.170
9	.582	.129	.328	.835
10	.283	.175	-.061	.626
11	.255	.120	.020	.491
12	.049	.066	-.081	.179
13	.071	.040	-.007	.148
14	.201	.147	-.088	.490
15	.315	.141	.039	.592
16	1.978	.513	.973	2.983
17	.505	.102	.306	.705
18	.168	.096	-.020	.357
19	1.630	.290	1.063	2.198
20	.386	.131	.130	.642
21	.185	.093	.002	.368

Tower of London Performance by 40-49 Year Olds (N = 174)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.856	.211	.443	1.270
2	.017	.057	-.094	.128
3	.230	.124	-.013	.472
4	.385	.101	.186	.584
5	.368	.112	.149	.587
6	.103	.095	-.082	.289
7	.253	.145	-.031	.537
8	.075	.058	-.038	.188
9	.523	.133	.262	.784
10	.448	.180	.095	.802
11	.241	.123	-.001	.484
12	.034	.068	-.100	.169
13	.040	.041	-.040	.120
14	.190	.151	-.107	.487
15	.391	.145	.106	.675
16	2.172	.527	1.139	3.206
17	.529	.104	.324	.734
18	.213	.099	.019	.407
19	1.264	.298	.680	1.848
20	.299	.134	.036	.562
21	.167	.096	-.021	.355

Tower of London Performance by 50-59 Year Olds (N = 144)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.090	.232	-.364	.544
2	.035	.062	-.087	.157
3	.250	.136	-.017	.517
4	.271	.111	.052	.489
5	.375	.123	.134	.616
6	.118	.104	-.086	.322
7	.361	.159	.049	.673
8	.056	.063	-.069	.180
9	.410	.146	.123	.696
10	.306	.198	-.083	.694
11	.208	.136	-.058	.474
12	.118	.075	-.029	.265
13	.069	.045	-.019	.157
14	.299	.166	-.028	.625
15	.444	.159	.132	.757
16	2.521	.579	1.385	3.657
17	.417	.115	.192	.642
18	.243	.109	.030	.456
19	1.556	.327	.914	2.198
20	.472	.148	.183	.762
21	.146	.105	-.061	.353

Tower of London Performance by 60-69 Year Olds (N = 186)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.253	.204	-.147	.652
2	.102	.055	-.005	.209
3	.565	.120	.330	.799
4	.554	.098	.361	.746
5	.478	.108	.267	.690
6	.204	.092	.025	.384
7	.333	.140	.059	.608
8	.097	.056	-.012	.206
9	.812	.129	.560	1.064
10	.575	.174	.233	.917
11	.344	.119	.110	.578
12	.065	.066	-.065	.194
13	.016	.039	-.061	.094
14	.414	.146	.127	.701
15	.763	.140	.488	1.039
16	3.005	.510	2.006	4.005
17	.543	.101	.345	.741
18	.296	.096	.108	.483
19	1.828	.288	1.263	2.393
20	.828	.130	.573	1.083
21	.231	.093	.049	.413

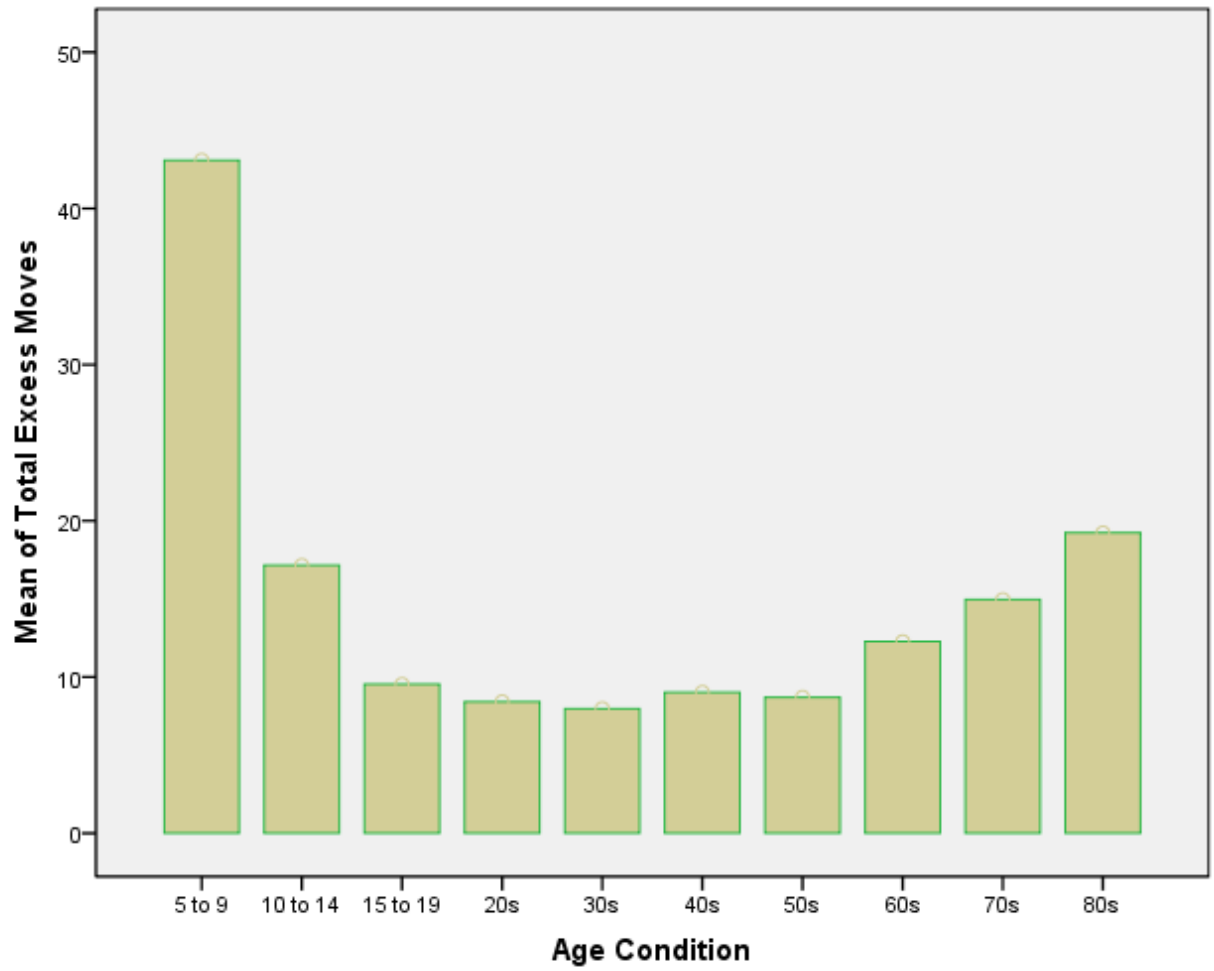
Tower of London Performance by 70-79 Year Olds (N = 225)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.120	.185	-.243	.483
2	.116	.050	.018	.213
3	.707	.109	.493	.920
4	.791	.089	.616	.966
5	.769	.098	.576	.961
6	.342	.083	.179	.505
7	.609	.127	.359	.859
8	.227	.051	.127	.326
9	.756	.117	.526	.985
10	.982	.159	.671	1.293
11	.324	.109	.112	.537
12	.276	.060	.158	.393
13	.071	.036	.001	.141
14	.596	.133	.334	.857
15	1.120	.128	.870	1.370
16	2.600	.464	1.691	3.509
17	.956	.092	.775	1.136
18	.453	.087	.283	.624
19	1.840	.262	1.326	2.354
20	1.022	.118	.791	1.254
21	.286	.084	.120	.451

Tower of London Performance by 80-89 Year Olds (N = 117)

Trial	Mean Errors	Standard Error	95% Lower Bound	95% Upper Bound
1	.248	.257	-.256	.752
2	.085	.069	-.050	.221
3	1.162	.151	.867	1.458
4	.615	.124	.373	.858
5	.838	.136	.571	1.105
6	.350	.115	.124	.577
7	.350	.177	.004	.697
8	.496	.070	.358	.633
9	1.265	.162	.947	1.583
10	1.009	.220	.578	1.440
11	1.026	.151	.730	1.321
12	.316	.083	.153	.480
13	.145	.050	.048	.243
14	.940	.185	.578	1.302
15	1.436	.177	1.089	1.783
16	3.855	.643	2.594	5.115
17	.991	.127	.742	1.241
18	.641	.121	.404	.878
19	1.538	.363	.826	2.251
20	1.573	.164	1.252	1.894
21	.359	.117	.130	.588

Total Excess Moves across 21 Tower of London Trails by Age Group



Tower of London First Move Think Time (msec)

across 21 Trials for 10 Age Groups

Tower of London First Move Time (MSEC) by 5-9 Year Olds (N = 126)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	7125.548	596.561	5955.135	8295.961
2	5564.341	495.077	4593.033	6535.650
3	6742.214	659.735	5447.859	8036.570
4	6726.056	562.435	5622.596	7829.515
5	6971.548	312.939	6357.582	7585.513
6	7866.341	388.170	7104.778	8627.905
7	8600.532	811.894	7007.649	10193.414
8	5774.397	313.116	5160.083	6388.710
9	7072.865	403.209	6281.795	7863.935
10	6482.651	458.318	5583.462	7381.839
11	6955.016	353.227	6262.009	7648.023
12	11070.810	1487.306	8152.815	13988.804
13	6525.698	521.589	5502.376	7549.021
14	8002.373	563.171	6897.469	9107.277
15	8028.579	847.111	6366.604	9690.554
16	7369.056	707.637	5980.720	8757.391
17	7592.937	579.860	6455.290	8730.583
18	8681.913	543.405	7615.789	9748.037
19	7043.944	766.955	5539.229	8548.660
20	8709.429	712.922	7310.724	10108.133
21	9700.698	608.594	8506.679	10894.718

Tower of London First Move Time (MSEC) by 10-14 Year Olds (N = 136)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	6075.684	574.210	4949.122	7202.245
2	4355.426	476.529	3420.509	5290.344
3	4162.706	635.017	2916.845	5408.566
4	5786.596	541.362	4724.479	6848.712
5	5887.963	301.214	5297.001	6478.926
6	5580.213	373.627	4847.183	6313.243
7	6629.485	781.476	5096.283	8162.688
8	5187.662	301.385	4596.364	5778.959
9	5358.029	388.102	4596.598	6119.460
10	4594.831	441.146	3729.332	5460.330
11	4150.640	339.993	3483.597	4817.682
12	4221.243	1431.582	1412.575	7029.910
13	4841.640	502.047	3856.658	5826.622
14	6810.816	542.071	5747.309	7874.323
15	7786.838	815.373	6187.132	9386.545
16	5078.456	681.124	3742.137	6414.775
17	5004.574	558.134	3909.551	6099.596
18	5465.735	523.045	4439.555	6491.915
19	6355.375	738.220	4907.036	7803.714
20	4316.676	686.211	2970.376	5662.976
21	5740.728	585.792	4591.444	6890.012

Tower of London First Move Time (MSEC) by 15-19 Year Olds (N = 258)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	5577.360	416.899	4759.433	6395.287
2	3772.682	345.978	3093.896	4451.468
3	3534.919	461.047	2630.376	4439.461
4	5552.895	393.050	4781.758	6324.033
5	5260.888	218.693	4831.826	5689.949
6	4881.806	271.267	4349.598	5414.014
7	6978.748	567.381	5865.584	8091.912
8	4337.364	218.817	3908.060	4766.669
9	4723.570	281.777	4170.742	5276.398
10	4377.488	320.289	3749.103	5005.874
11	3692.864	246.848	3208.566	4177.163
12	3573.357	1039.383	1534.156	5612.557
13	4645.682	364.505	3930.547	5360.817
14	6069.395	393.564	5297.248	6841.542
15	7192.442	591.992	6030.993	8353.890
16	6886.391	494.522	5916.172	7856.611
17	4462.795	405.227	3667.766	5257.823
18	4500.523	379.751	3755.477	5245.569
19	6952.837	535.976	5901.288	8004.387
20	4120.481	498.216	3143.015	5097.946
21	5246.992	425.307	4412.568	6081.417

Tower of London First Move Time (MSEC) by 20-29 Year Olds (N = 285)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	5857.898	396.659	5079.679	6636.117
2	3598.761	329.182	2952.929	4244.594
3	3828.537	438.664	2967.907	4689.167
4	5715.239	373.969	4981.537	6448.940
5	4967.270	208.076	4559.038	5375.502
6	5115.281	258.098	4608.910	5621.652
7	7086.189	539.837	6027.066	8145.313
8	4165.326	208.194	3756.863	4573.790
9	5047.446	268.098	4521.456	5573.436
10	4418.642	304.740	3820.763	5016.521
11	3494.039	234.864	3033.251	3954.826
12	4559.596	988.925	2619.393	6499.800
13	4635.460	346.810	3955.042	5315.877
14	6351.561	374.458	5616.900	7086.223
15	7026.674	563.253	5921.610	8131.737
16	6826.091	470.515	5902.973	7749.209
17	4429.656	385.555	3673.224	5186.088
18	4399.930	361.315	3691.053	5108.806
19	8426.456	509.956	7425.956	9426.956
20	4521.498	474.029	3591.486	5451.511
21	5465.568	404.660	4671.653	6259.484

Tower of London First Move Time (MSEC) by 30-39 Year Olds (N = 82)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	7390.720	739.492	5939.886	8841.553
2	4027.122	613.693	2823.097	5231.147
3	4461.280	817.801	2856.809	6065.752
4	7662.866	697.189	6295.027	9030.704
5	6217.744	387.917	5456.678	6978.810
6	5799.805	481.172	4855.778	6743.832
7	8222.317	1006.417	6247.794	10196.840
8	5112.085	388.136	4350.588	5873.583
9	5871.671	499.815	4891.068	6852.273
10	6253.317	568.126	5138.691	7367.943
11	4389.427	437.857	3530.381	5248.472
12	4232.280	1843.651	615.161	7849.400
13	6514.098	646.557	5245.597	7782.599
14	7792.049	698.102	6422.420	9161.678
15	9224.610	1050.071	7164.441	11284.779
16	9109.573	877.180	7388.605	10830.541
17	5766.573	718.789	4356.357	7176.789
18	5644.098	673.600	4322.540	6965.655
19	9769.732	950.711	7904.501	11634.963
20	5550.232	883.731	3816.410	7284.053
21	6744.183	754.407	5264.087	8224.279

Tower of London First Move Time (MSEC) by 40-49 Year Olds (N = 73)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	8082.438	783.752	6544.769	9620.108
2	4396.014	650.425	3119.924	5672.103
3	4419.041	866.749	2718.538	6119.544
4	6944.342	738.918	5494.635	8394.050
5	6090.836	411.134	5284.217	6897.454
6	6139.904	509.971	5139.375	7140.434
7	8273.274	1066.654	6180.571	10365.977
8	5280.986	411.367	4473.911	6088.061
9	5731.877	529.730	4692.582	6771.171
10	6608.685	602.130	5427.346	7790.024
11	4410.055	464.064	3499.593	5320.516
12	4911.904	1953.998	1078.290	8745.518
13	6015.356	685.255	4670.932	7359.780
14	7184.260	739.885	5732.655	8635.865
15	9943.479	1112.921	7760.004	12126.955
16	8332.479	929.681	6508.507	10156.452
17	5264.685	761.810	3770.064	6759.306
18	5363.452	713.917	3962.796	6764.108
19	11297.247	1007.613	9320.376	13274.117
20	5313.712	936.625	3476.117	7151.308
21	7881.808	799.560	6313.124	9450.492

Tower of London First Move Time (MSEC) by 50-59 Year Olds (N = 65)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	9921.431	830.584	8291.881	11550.981
2	8507.831	689.290	7155.491	9860.171
3	4892.108	918.540	3089.994	6694.222
4	8488.908	783.071	6952.576	10025.240
5	6629.046	435.701	5774.230	7483.862
6	6347.554	540.444	5287.240	7407.868
7	9589.754	1130.390	7372.005	11807.503
8	6028.262	435.948	5172.961	6883.562
9	7636.077	561.383	6534.681	8737.472
10	7433.231	638.109	6181.303	8685.159
11	4936.862	491.793	3971.997	5901.726
12	5265.046	2070.756	1202.362	9327.731
13	7553.415	726.201	6128.658	8978.173
14	9109.431	784.096	7571.088	10647.774
15	10297.246	1179.421	7983.301	12611.192
16	11328.785	985.233	9395.824	13261.745
17	6902.246	807.331	5318.317	8486.175
18	7012.108	756.575	5527.758	8496.458
19	13200.708	1067.822	11105.713	15295.702
20	6748.831	992.591	4801.433	8696.228
21	8651.708	847.337	6989.290	10314.125

Tower of London First Move Time (MSEC) by 60-69 Year Olds (N = 73)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	11808.671	783.752	10271.002	13346.341
2	5261.521	650.425	3985.431	6537.610
3	5198.384	866.749	3497.880	6898.887
4	10512.466	738.918	9062.758	11962.173
5	7074.411	411.134	6267.793	7881.029
6	7307.123	509.971	6306.594	8307.653
7	11270.644	1066.654	9177.941	13363.347
8	5945.973	411.367	5138.898	6753.048
9	8112.493	529.730	7073.199	9151.788
10	6243.425	602.130	5062.086	7424.764
11	5542.384	464.064	4631.922	6452.845
12	5733.301	1953.998	1899.688	9566.915
13	7106.110	685.255	5761.685	8450.534
14	8819.274	739.885	7367.669	10270.879
15	12556.452	1112.921	10372.976	14739.928
16	10508.521	929.681	8684.548	12332.493
17	6620.726	761.810	5126.105	8115.347
18	6932.521	713.917	5531.864	8333.177
19	11796.260	1007.613	9819.390	13773.130
20	7926.616	936.625	6089.021	9764.212
21	9646.603	799.560	8077.919	11215.287

Tower of London First Move Time (MSEC) by 70-79 Year Olds (N = 92)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	14456.424	698.146	13086.708	15826.140
2	8093.891	579.381	6957.184	9230.599
3	7017.185	772.077	5502.421	8531.949
4	13766.207	658.209	12474.845	15057.568
5	9244.022	366.228	8525.507	9962.536
6	11050.815	454.269	10159.570	11942.061
7	14750.457	950.147	12886.331	16614.582
8	9845.413	366.435	9126.492	10564.335
9	10053.033	471.870	9127.256	10978.809
10	9329.935	536.362	8277.629	10382.241
11	8370.185	413.376	7559.169	9181.200
12	8888.685	1740.571	5473.801	12303.568
13	11979.870	610.407	10782.292	13177.448
14	12108.587	659.070	10815.535	13401.639
15	16603.902	991.361	14658.919	18548.885
16	11319.815	828.136	9695.068	12944.562
17	10410.391	678.601	9079.022	11741.761
18	11591.250	635.938	10343.582	12838.918
19	15246.087	897.556	13485.143	17007.031
20	11723.522	834.321	10086.640	13360.404
21	12579.630	712.228	11182.288	13976.973

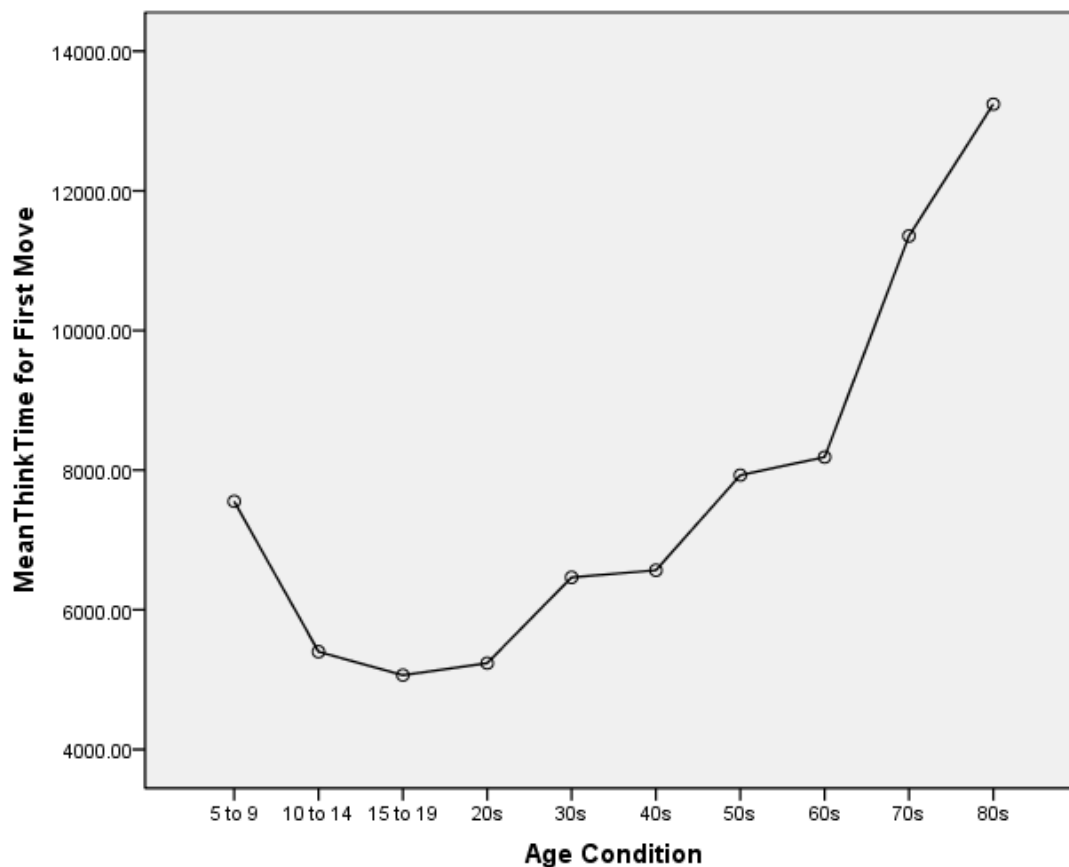
Tower of London First Move Time (MSEC) by 80-89 Year Olds (N = 26)

Trial	Mean Time	Standard Error	95% Lower Bound	95% Upper Bound
1	16161.538	1313.269	13584.994	18738.083
2	11282.038	1089.862	9143.801	13420.276
3	9653.731	1452.339	6804.339	12503.123
4	15913.962	1238.143	13484.807	18343.116
5	11360.423	688.904	10008.840	12712.006
6	11576.808	854.517	9900.304	13253.312
7	18071.577	1787.303	14565.008	21578.146
8	10706.269	689.294	9353.920	12058.618
9	12586.692	887.624	10845.233	14328.152
10	9366.077	1008.940	7386.605	11345.549
11	7514.154	777.593	5988.569	9039.739
12	12377.231	3274.153	5953.562	18800.899
13	13655.077	1148.225	11402.337	15907.817
14	19365.154	1239.764	16932.820	21797.488
15	22957.423	1864.829	19298.754	26616.092
16	14432.846	1557.790	11376.567	17489.125
17	9577.385	1276.502	7072.973	12081.797
18	13354.731	1196.251	11007.767	15701.694
19	13734.692	1688.374	10422.215	17047.169
20	8764.923	1569.425	5685.817	11844.029
21	15660.231	1339.757	13031.718	18288.744

Mean First Move Planning Time in Msec. for Tower of London Problems

MeanThinkTime

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
5 to 9	126	7552.7116	4319.15988	384.78134	6791.1816	8314.2417	3640.29	36825.67
10 to 14	136	5399.5865	1422.48505	121.97709	5158.3533	5640.8196	2337.76	10051.76
15 to 19	258	5063.8800	1947.83372	121.26683	4825.0768	5302.6832	2434.14	16183.10
20s	285	5235.1009	2024.44372	119.91770	4999.0607	5471.1412	2456.29	18741.43
30s	82	6464.5610	2559.76947	282.67925	5902.1179	7027.0040	2520.33	21016.57
40s	73	6565.9922	4279.01394	500.82070	5567.6244	7564.3600	2990.95	38087.95
50s	65	7927.6469	3547.94102	440.06792	7048.5101	8806.7836	3077.81	18105.81
60s	73	8186.8513	4745.86973	555.46204	7079.5579	9294.1446	2810.81	32689.86
70s	92	11353.7764	6447.27751	672.17515	10018.5830	12688.9698	3234.76	43192.95
80s	26	13241.5696	6202.26314	1216.36388	10736.4213	15746.7179	2823.14	30397.10
Total	1216	6575.3677	3927.32435	112.62375	6354.4091	6796.3263	2337.76	43192.95



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Appendix A.

[Insert Introduction to Appendix A here]

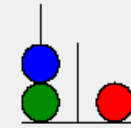
Structural Problem Parameters

TOL321 Berg[63-52] Peg[12!3!-32!!1] Ball[121121-311112]

Start State



Goal State



Minimum Moves: 2

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
comp. amb. hierarchy (110)

Goal: partial tower (210)
comp. amb. hierarchy (110)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start




1 / 2

2 / 2

#001

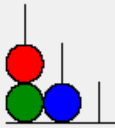

Depth: 0 + 2

ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[63-66] Peg[12!3!-!23!1] Ball[121121-312221]

Minimum Moves: 2

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
unamb. hierarchy (200)

Goal: partial tower (210)
comp. amb. hierarchy (110)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start




1 / 2

2 / 2

#001



Depth: 0 + 2

ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[63-55] Peg[12!3!-2!1!3] Ball[121121-211131]

Minimum Moves: 2

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
comp. amb. hierarchy (110)

Goal: flat tower (111)
comp. amb. hierarchy (110)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start




1 / 2

2 / 2

#001

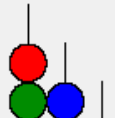
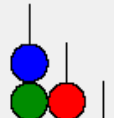
Depth: 0 + 2

ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[63-53] Peg[12!3!-32!1!] Ball[121121-211112]

Start State:  Goal State: 

Minimum Moves: 3 Suboptimal Paths: 0 Start: partial tower (210)
 Optimal Paths: 2 Detours: 0 comp. amb. hierarchy (110)
 Search Depth: 1 Dead Ends: 0 Goal: partial tower (210)
 comp. amb. hierarchy (110)

Display ...

[Optimal Paths](#)





[Suboptimal Paths](#)

[Iso-Problems](#)





Optimal Paths

Start 1 / 3 2 / 3 3 / 3

#001
 Depth: 1 + 2
 ContPaths: 1 / 0

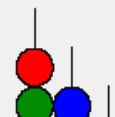
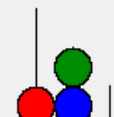
   

#002
 Depth: 1 + 2
 ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[63-14] Peg[12!3!-1!23!] Ball[121121-112221]

Start State:  Goal State: 

Minimum Moves: 3 Suboptimal Paths: 1 Start: partial tower (210)
 Optimal Paths: 1 Detours: 1 unamb. hierarchy (200)
 Search Depth: 1 Dead Ends: 0 Goal: partial tower (210)
 comp. amb. hierarchy (110)

Display ...

[Optimal Paths](#)





[Suboptimal Paths](#)

[Iso-Problems](#)

Optimal Paths


Start 1 / 3 2 / 3 3 / 3

#001
 Depth: 1 + 2
 ContPaths: 1 / 0


   

Structural Problem Parameters

TOL321 Berg[63-13] Peg[12!3!-21!3!] Ball[121121-111221]



Start State



Goal State

Minimum Moves: 4

Optimal Paths: 2

Search Depth: 2

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0











Start: partial tower (210)
unamb. hierarchy (200)

Goal: partial tower (210)
unamb. hierarchy (200)

Display ...

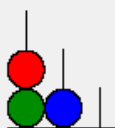
Optimal Paths
Suboptimal Paths
Iso-Problems

Optimal Paths

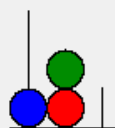
	Start	1 / 4	2 / 4	3 / 4	4 / 4
#001 Depth: 2 + 2 ContPaths: 1 / 0					
#002 Depth: 2 + 2 ContPaths: 1 / 0					

Structural Problem Parameters

TOL321 Berg[63-44] Peg[12!3!-3!21!] Ball[121121-212211]



Start State



Goal State

Minimum Moves: 4

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0






Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)

Display ...

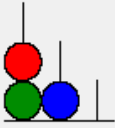
Optimal Paths
Suboptimal Paths
Iso-Problems

Optimal Paths


	Start	1 / 4	2 / 4	3 / 4	4 / 4
#001 Depth: 1 + 3 ContPaths: 1 / 0					

Structural Problem Parameters

TOL321 Berg[63-22] Peg[12!3!-31!!2] Ball[121121-113112]



Start State



Goal State

Minimum Moves: 4

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 2

Detours: 1

Dead Ends: 1

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start

1 / 4

2 / 4






3 / 4

4 / 4

#001


Depth: 1 + 3

ContPaths: 1 / 0








Structural Problem Parameters

TOL321 Berg[63-46] Peg[12!3!-!31!2] Ball[121121-213122]



Start State



Goal State

Minimum Moves: 4

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 3

Detours: 1

Dead Ends: 2

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start

1 / 4

2 / 4






3 / 4

4 / 4

#001


Depth: 1 + 3

ContPaths: 1 / 0








Structural Problem Parameters

TOL321 Berg[63-11] Peg[12!3!-321!!] Ball[121121-111213]



Start State



Goal State

Minimum Moves: 5

Optimal Paths: 2

Search Depth: 2

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0













Start: partial tower (210)
part. amb. hierarchy (210)

Goal: full tower (300)
unamb. hierarchy (300)

Display ...

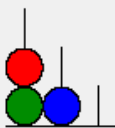
Optimal Paths
Suboptimal Paths
Iso-Problems

Optimal Paths


	Start	1 / 5	2 / 5	3 / 5	4 / 5	5 / 5
#001 Depth: 2 + 3 ContPaths: 1 / 0						
#002 Depth: 2 + 3 ContPaths: 1 / 0						

Structural Problem Parameters

TOL321 Berg[63-21] Peg[12!3!-231!!] Ball[121121-111312]



Start State



Goal State

Minimum Moves: 5

Optimal Paths: 1

Search Depth: 2

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0







Start: partial tower (210)
part. amb. hierarchy (210)

Goal: full tower (300)
unamb. hierarchy (300)

Display ...

Optimal Paths
Suboptimal Paths
Iso-Problems

Optimal Paths

	Start	1 / 5	2 / 5	3 / 5	4 / 5	5 / 5
#001 Depth: 2 + 3 ContPaths: 1 / 0						

Structural Problem Parameters

TOL321 Berg[63-43] Peg[12!3!-23!1!] Ball[121121-211211]

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Minimum Moves: 5

Suboptimal Paths: 1

Start: partial tower (210)
part. amb. hierarchy (210)

Optimal Paths: 1

Detours: 1

Goal: partial tower (210)
part. amb. hierarchy (210)

Search Depth: 1

Dead Ends: 0

Start State

Goal State

Optimal Paths

Start 1 / 5 2 / 5 3 / 5 4 / 5 5 / 5

#001

Depth: 1 + 4

ContPaths: 1 / 1

Structural Problem Parameters

TOL321 Berg[63-45] Peg[12!3!-3!1!2] Ball[121121-213111]

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Minimum Moves: 5

Suboptimal Paths: 3

Start: partial tower (210)
part. amb. hierarchy (210)

Optimal Paths: 2

Detours: 1

Goal: flat tower (111)
comp. amb. hierarchy (111)

Search Depth: 1

Dead Ends: 2

Start State

Goal State

Optimal Paths

Start 1 / 5 2 / 5 3 / 5 4 / 5 5 / 5

#001

Depth: 1 + 4

ContPaths: 2 / 0

#002


Depth: 1 + 4

ContPaths: 2 / 0


Appendix B.

Structural Problem Parameters

TOL321 Berg[43-41] Peg[23!1!-123!!] Ball[211211-131211]



Start State



Goal State

Minimum Moves: 1

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
unamb. hierarchy (100)

Goal: full tower (300)
unamb. hierarchy (100)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems



Optimal Paths

Start 1 / 1

#001


Depth: 0 + 1

ContPaths: 0 / 0





Structural Problem Parameters

TOL321 Berg[36-24] Peg[!32!1-1!32!] Ball[312122-112122]



Start State



Goal State

Minimum Moves: 1

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
unamb. hierarchy (100)

Goal: partial tower (210)
unamb. hierarchy (100)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems



Optimal Paths

Start 1 / 1

#001

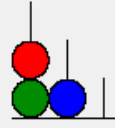

Depth: 0 + 1

ContPaths: 0 / 0

Structural Problem Parameters

TOL321 Berg[63-64] Peg[12!3!-2!13!] Ball[121121-221121]

Minimum Moves: 1

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
unamb. hierarchy (100)

Goal: partial tower (210)
unamb. hierarchy (100)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems



Optimal Paths

Start 1 / 1

#001



Depth: 0 + 1

ContPaths: 0 / 0

Structural Problem Parameters

TOL321 Berg[52-65] Peg[32!!1-2!3!1] Ball[311112-311121]

Minimum Moves: 1

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
unamb. hierarchy (100)

Goal: flat tower (111)
unamb. hierarchy (100)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems



Optimal Paths

Start 1 / 1

#001


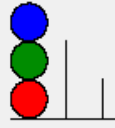
Depth: 0 + 1

ContPaths: 0 / 0

Structural Problem Parameters

TOL321 Berg[14-11] Peg[1!23!-321!!] Ball[112221-111213]

Minimum Moves: 2

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
unamb. hierarchy (200)

Goal: full tower (300)
unamb. hierarchy (200)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start




1 / 2

2 / 2

#001

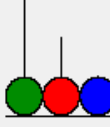
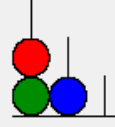
Depth: 0 + 2

ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[55-63] Peg[2!1!3-12!3!] Ball[211131-121121]

Minimum Moves: 2

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: flat tower (111)
comp. amb. hierarchy (110)

Goal: partial tower (210)
comp. amb. hierarchy (110)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start



1 / 2

2 / 2

#001


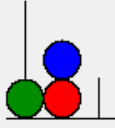
Depth: 0 + 2

ContPaths: 1 / 0


Structural Problem Parameters

TOL321 Berg[65-54] Peg[2!3!1-2!31!] Ball[311121-211122]

Minimum Moves: 3

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0

Start: flat tower (111)
comp. amb. hierarchy (110)

Goal: partial tower (210)
unamb. hierarchy (200)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems


Optimal Paths

Start 1 / 3 2 / 3 3 / 3

#001


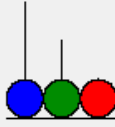
Depth: 1 + 2

ContPaths: 1 / 0



Structural Problem Parameters

TOL321 Berg[23-35] Peg[3!2!-3!2!1] Ball[112112-312111]

Minimum Moves: 3

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0

Start: partial tower (210)
unamb. hierarchy (200)

Goal: flat tower (111)
comp. amb. hierarchy (110)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems


Optimal Paths

Start 1 / 3 2 / 3 3 / 3

#001


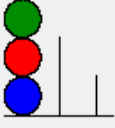
Depth: 1 + 2

ContPaths: 1 / 0



Structural Problem Parameters

TOL321 Berg[26-31] Peg[!12!3-2!3!1] Ball[222131-121311]

Minimum Moves: 3

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: full tower (300)
unamb. hierarchy (300)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems


Optimal Paths

Start 1 / 3 2 / 3 3 / 3

#001



Depth: 0 + 3

ContPaths: 1 / 0



Structural Problem Parameters

TOL321 Berg[46-33] Peg[!3!2-13!2!] Ball[213122-122111]

Minimum Moves: 3

Optimal Paths: 1

Search Depth: 0

Suboptimal Paths: 0

Detours: 0

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start

1 / 3





2 / 3

3 / 3

#001



Depth: 0 + 3

ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[15-63] Peg[!1!3!2-12!3!] Ball[113121-121121]

Minimum Moves: 3

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0

Start: flat tower (111)
comp. amb. hierarchy (110)

Goal: partial tower (210)
unamb. hierarchy (200)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start

1 / 3





2 / 3

3 / 3

#001

Depth: 1 + 2

ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[14-25] Peg[1!23!-1!2!3] Ball[112221-112131]

Minimum Moves: 3 Suboptimal Paths: 1 Start: partial tower (210)
 Optimal Paths: 1 Detours: 1 unamb. hierarchy (200)
 Search Depth: 1 Dead Ends: 0 Goal: flat tower (111)
 comp. amb. hierarchy (110)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 3 2 / 3 3 / 3

#001
 Depth: 1 + 2
 ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[14-51] Peg[1!23!-132!!] Ball[112221-131112]

Minimum Moves: 4 Suboptimal Paths: 1 Start: partial tower (210)
 Optimal Paths: 1 Detours: 1 part. amb. hierarchy (210)
 Search Depth: 1 Dead Ends: 0 Goal: full tower (300)
 unamb. hierarchy (300)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 4 2 / 4 3 / 4 4 / 4

#001
 Depth: 1 + 3
 ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[23-64] Peg[3!12!-2!13!] Ball[112112-221121]

Minimum Moves: 4 Suboptimal Paths: 1 Start: partial tower (210)
 Optimal Paths: 1 Detours: 1 part. amb. hierarchy (210)
 Search Depth: 1 Dead Ends: 0 Goal: partial tower (210)
 part. amb. hierarchy (210)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 4 2 / 4 3 / 4 4 / 4

#001
 Depth: 1 + 3
 ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[22-63] Peg[31!!2-12!3!] Ball[1131112-121121]

Minimum Moves: 4 Suboptimal Paths: 1 Start: partial tower (210)
 Optimal Paths: 1 Detours: 1 part. amb. hierarchy (210)
 Search Depth: 0 Dead Ends: 0 Goal: partial tower (210)
 part. amb. hierarchy (210)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 4 2 / 4 3 / 4 4 / 4

#001
 Depth: 0 + 4
 ContPaths: 1 / 1

Structural Problem Parameters

TOL321 Berg[46-65] Peg[!31!2-2!3!1] Ball[2131122-311121]

Minimum Moves: 4 Suboptimal Paths: 3 Start: partial tower (210)
 Optimal Paths: 1 Detours: 1 part. amb. hierarchy (210)
 Search Depth: 0 Dead Ends: 2 Goal: flat tower (111)
 comp. amb. hierarchy (111)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 4 2 / 4 3 / 4 4 / 4

#001
 Depth: 0 + 4
 ContPaths: 1 / 1

Structural Problem Parameters

TOL321 Berg[23-41] Peg[31!2!-123!!] Ball[1121112-131211]

Minimum Moves: 5 Suboptimal Paths: 1 Start: partial tower (210)
 Optimal Paths: 1 Detours: 1 part. amb. hierarchy (210)
 Search Depth: 2 Dead Ends: 0 Goal: full tower (300)
 unamb. hierarchy (300)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 5 2 / 5 3 / 5 4 / 5 5 / 5

#001
 Depth: 2 + 3
 ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[15-55] Peg[1!3!2-2!1!3] Ball[113121-211131]

Minimum Moves: 5 Suboptimal Paths: 3 Start: flat tower (111)
comp. amb. hierarchy (111)

Optimal Paths: 1 Detours: 1

Search Depth: 1 Dead Ends: 2 Goal: flat tower (111)
comp. amb. hierarchy (111)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 5 2 / 5 3 / 5 4 / 5 5 / 5

#001
Depth: 1 + 4
ContPaths: 1 / 1

Structural Problem Parameters

TOL321 Berg[52-11] Peg[32!!1-321!!] Ball[311112-111213]

Minimum Moves: 5 Suboptimal Paths: 1 Start: partial tower (210)
part. amb. hierarchy (210)

Optimal Paths: 1 Detours: 1

Search Depth: 2 Dead Ends: 0 Goal: full tower (300)
unamb. hierarchy (300)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 5 2 / 5 3 / 5 4 / 5 5 / 5

#001
Depth: 2 + 3
ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[43-63] Peg[23!1!-12!3!] Ball[211211-121121]

Minimum Moves: 5 Suboptimal Paths: 1 Start: partial tower (210)
part. amb. hierarchy (210)

Optimal Paths: 1 Detours: 1

Search Depth: 2 Dead Ends: 0 Goal: partial tower (210)
part. amb. hierarchy (210)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems


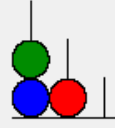
Optimal Paths

Start 1 / 5 2 / 5 3 / 5 4 / 5 5 / 5

#001
Depth: 2 + 3
ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[63-43] Peg[12!3!-23!1!] Ball[121121-211211]

Minimum Moves: 5

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)







Display ...

Optimal Paths

Suboptimal Paths

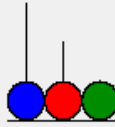
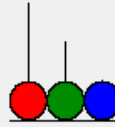
Iso-Problems

Optimal Paths

	Start	1 / 5	2 / 5	3 / 5	4 / 5	5 / 5
#001						
Depth: 1 + 4						
ContPaths: 1 / 1						

Structural Problem Parameters

TOL321 Berg[45-25] Peg[3!1!2-1!2!3] Ball[213111-112131]

Minimum Moves: 5

Optimal Paths: 1

Search Depth: 1

Suboptimal Paths: 3

Detours: 1

Dead Ends: 2

Start: flat tower (111)
comp. amb. hierarchy (111)

Goal: flat tower (111)
comp. amb. hierarchy (111)







Display ...

Optimal Paths

Suboptimal Paths


Iso-Problems

Optimal Paths


	Start	1 / 5	2 / 5	3 / 5	4 / 5	5 / 5
#001						
Depth: 1 + 4						
ContPaths: 1 / 1						

Structural Problem Parameters

TOL321 Berg[12-51] Peg[21!!3-132!!] Ball[111231-131112]



Start State



Goal State

Minimum Moves: 6

Optimal Paths: 1

Search Depth: 3

Suboptimal Paths: 2

Detours: 2

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: full tower (300)
unamb. hierarchy (300)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems








Optimal Paths

Start 1 / 6 2 / 6 3 / 6 4 / 6 5 / 6 6 / 6

#001

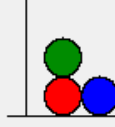
Depth: 3 + 3

ContPaths: 1 / 0

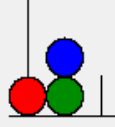








Structural Problem Parameters

TOL321 Berg[56-24] Peg[!21!3-1!32!] Ball[212231-112122]



Start State



Goal State

Minimum Moves: 6

Optimal Paths: 1

Search Depth: 3

Suboptimal Paths: 5

Detours: 5

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems








Optimal Paths

Start 1 / 6 2 / 6 3 / 6 4 / 6 5 / 6 6 / 6

#001

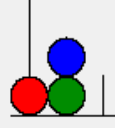
Depth: 3 + 3

ContPaths: 1 / 0

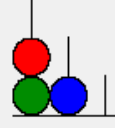








Structural Problem Parameters

TOL321 Berg[24-63] Peg[!132!-12!3!] Ball[112122-121121]



Start State



Goal State

Minimum Moves: 6

Optimal Paths: 1

Search Depth: 2

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems








Optimal Paths

Start 1 / 6 2 / 6 3 / 6 4 / 6 5 / 6 6 / 6

#001

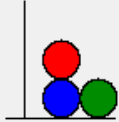

Depth: 2 + 4

ContPaths: 1 / 1

Structural Problem Parameters

TOL321 Berg[16-35] Peg[13!2-3!2!1] Ball[223121-312111]

Start State:  Goal State: 

Minimum Moves: 6 Suboptimal Paths: 5 Start: partial tower (210)
 Optimal Paths: 1 Detours: 2 part. amb. hierarchy (210)
 Search Depth: 2 Dead Ends: 3 Goal: flat tower (111)
 comp. amb. hierarchy (111)

Display ...

[Optimal Paths](#)








[Suboptimal Paths](#)

[Iso-Problems](#)

Optimal Paths

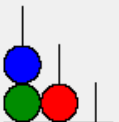

Start 1 / 6 2 / 6 3 / 6 4 / 6 5 / 6 6 / 6

#001
 Depth: 2 + 4
 ContPaths: 1 / 1

Structural Problem Parameters

TOL321 Berg[53-11] Peg[32!1!-321!!] Ball[211112-111213]

Start State:  Goal State: 

Minimum Moves: 6 Suboptimal Paths: 3 Start: partial tower (210)
 Optimal Paths: 1 Detours: 3 part. amb. hierarchy (210)
 Search Depth: 3 Dead Ends: 0 Goal: full tower (300)
 unamb. hierarchy (300)

Display ...

[Optimal Paths](#)








[Suboptimal Paths](#)

[Iso-Problems](#)

Optimal Paths

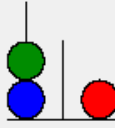

Start 1 / 6 2 / 6 3 / 6 4 / 6 5 / 6 6 / 6

#001
 Depth: 3 + 3
 ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[42-63] Peg[23!!1-12!3!] Ball[311211-121121]

Minimum Moves: 6

Optimal Paths: 1

Search Depth: 3

Suboptimal Paths: 5

Detours: 5

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)








Display ...

Optimal Paths

Suboptimal Paths


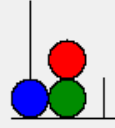
Iso-Problems

Optimal Paths

	Start	1 / 6	2 / 6	3 / 6	4 / 6	5 / 6	6 / 6
#001							
Depth: 3 + 3							
ContPaths: 1 / 0							

Structural Problem Parameters

TOL321 Berg[53-34] Peg[32!1!-3!12!] Ball[211112-222111]

Minimum Moves: 6

Optimal Paths: 1

Search Depth: 2

Suboptimal Paths: 1

Detours: 1

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)








Display ...

Optimal Paths

Suboptimal Paths

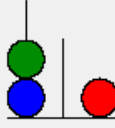
Iso-Problems

Optimal Paths


	Start	1 / 6	2 / 6	3 / 6	4 / 6	5 / 6	6 / 6
#001							
Depth: 2 + 4							
ContPaths: 1 / 1							

Structural Problem Parameters

TOL321 Berg[42-15] Peg[23!!1-1!3!2] Ball[311211-113121]



Start State



Goal State

Minimum Moves: 6

Optimal Paths: 1

Search Depth: 2

Suboptimal Paths: 5

Detours: 2

Dead Ends: 3

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: flat tower (111)
comp. amb. hierarchy (111)

Display ...

Optimal Paths
Suboptimal Paths
Iso-Problems


Optimal Paths

Start
1 / 6
2 / 6
3 / 6
4 / 6
5 / 6
6 / 6

#001

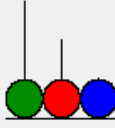
Depth: 2 + 4

ContPaths: 1 / 1




Structural Problem Parameters

TOL321 Berg[55-21] Peg[2!1!3-231!!] Ball[211131-111312]



Start State



Goal State

Minimum Moves: 7

Optimal Paths: 1

Search Depth: 4

Suboptimal Paths: 4

Detours: 4

Dead Ends: 0

Start: flat tower (111)
comp. amb. hierarchy (111)

Goal: full tower (300)
unamb. hierarchy (300)

Display ...

Optimal Paths
Suboptimal Paths
Iso-Problems


Optimal Paths

Start
1 / 7
2 / 7
3 / 7
4 / 7
5 / 7
6 / 7
7 / 7

#001

Depth: 4 + 3

ContPaths: 1 / 0



Structural Problem Parameters

TOL321 Berg[24-55] Peg[1!32!-2!1!3] Ball[112122-211131]

Minimum Moves: 7 Suboptimal Paths: 6 Start: partial tower (210)
 Optimal Paths: 1 Detours: 3 part. amb. hierarchy (210)
 Search Depth: 3 Dead Ends: 3 Goal: flat tower (111)
 comp. amb. hierarchy (111)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start 1 / 7 2 / 7 3 / 7 4 / 7 5 / 7 6 / 7 7 / 7

#001
 Depth: 3 + 4
 ContPaths: 1 / 1

Structural Problem Parameters

TOL321 Berg[24-61] Peg[1!32!-3!2!!] Ball[112122-121113]

Minimum Moves: 7 Suboptimal Paths: 6 Start: partial tower (210)
 Optimal Paths: 1 Detours: 6 part. amb. hierarchy (210)
 Search Depth: 4 Dead Ends: 0 Goal: full tower (300)
 unamb. hierarchy (300)

Start State Goal State

Display ...

Optimal Paths

Suboptimal Paths

Iso-Problems

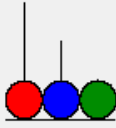

Optimal Paths

Start 1 / 7 2 / 7 3 / 7 4 / 7 5 / 7 6 / 7 7 / 7

#001
 Depth: 4 + 3
 ContPaths: 1 / 0

Structural Problem Parameters

TOL321 Berg[15-43] Peg[1!3!2-23!1!] Ball[113121-211211]

Minimum Moves: 7

Optimal Paths: 1

Search Depth: 4

Suboptimal Paths: 7

Detours: 7

Dead Ends: 0

Start: flat tower (111)
comp. amb. hierarchy (111)

Goal: partial tower (210)
part. amb. hierarchy (210)









Display ...

Optimal Paths

Suboptimal Paths


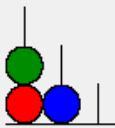
Iso-Problems

Optimal Paths

	Start	1 / 7	2 / 7	3 / 7	4 / 7	5 / 7	6 / 7	7 / 7
#001								
Depth: 4 + 3								
ContPaths: 1 / 0								

Structural Problem Parameters

TOL321 Berg[46-13] Peg[!3!12-21!3!] Ball[213122-111221]

Minimum Moves: 7

Optimal Paths: 1

Search Depth: 3

Suboptimal Paths: 7

Detours: 7

Dead Ends: 0

Start: partial tower (210)
part. amb. hierarchy (210)

Goal: partial tower (210)
part. amb. hierarchy (210)









Display ...

Optimal Paths

Suboptimal Paths

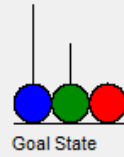
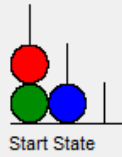
Iso-Problems

Optimal Paths

	Start	1 / 7	2 / 7	3 / 7	4 / 7	5 / 7	6 / 7	7 / 7
#001								
Depth: 3 + 4								
ContPaths: 1 / 1								

Structural Problem Parameters

TOL321 Berg[63-35] Peg[12!3!-3!2!1] Ball[121121-312111]



Minimum Moves: 7

Suboptimal Paths: 6

Start: partial tower (210)
part. amb. hierarchy (210)

Optimal Paths: 1

Detours: 3

Goal: flat tower (111)
comp. amb. hierarchy (111)

Search Depth: 3

Dead Ends: 3

— Display ... —

Optimal Paths

Suboptimal Paths

Iso-Problems

Optimal Paths

Start

117

217

317

417

517

617

717

#001

Depth: 3 + 4

ContPaths: 1 / 1



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