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Induced Creativity Improves Relational Transfer

Aaron L. Wu

Abstract

This experiment aimed to assess induced creativity on the transfer of a relational strategy. Creativity was operationally defined by the semantic distance within an analogical completion task. Semantic distance refers to the relative association between two concepts or, in this case, two analogical pairs. More creative analogies were termed as “far” analogies because the associative distance was greater, often involving two separate domains. Less creative analogies were termed as “near” analogies because the associative distance was smaller, often only involving a single domain. We hypothesized that by varying the amount of semantic distance, we would be able to induce more or less transfer of a relational strategy utilized in a verbal analogy task, to a pictoral analogy task. This transfer was dependent on more than just the performance of analogies alone, but relied on the specific condition of some threshold creativity induced by high semantic distance trials. The results confirmed this hypothesis, finding a significant difference in the proportion of relational responses in the pictoral analogy from those that performed far analogies in the verbal analogy task than those that performed the near analogies, p= .005. These results also accounted for similarity scores as well as fluid intelligence. Therefore, there is some process that occurs when performing analogies of high semantic distance that allows conferring strategies between tasks, perhaps by priming of certain brain regions, or by a switching on different networks.
The purpose of this study is to explore the limits of transfer induced by creativity.

Transfer refers to the ability to utilize processes from one task in order to aid in the completion of another task that shares certain components with the first task. For example, one task could be purely verbal and only use words to represent concepts while another task could utilize images, but both could be structured as analogies. The process of transfer is critical in problem solving and creativity, allowing people to utilize previous experiences and associations in order to resolve novel problems. However, it is unknown the mechanisms or requisites for transfer. Thought unlikely, it may well be that transfer is be restricted to certain tasks that utilize certain brain regions more than others. Far analogies have been shown to demand more cognitive resources (Green et al., 2006/2009) as demonstrated with increased response times, decrements in performance, and increases in neural activation over and above more semantically distant analogies. It could be that these relatively recent patterns of neural activation that result in an increased likelihood of subsequent firing of the same or similar patterns in the same areas, given the proper stimulating conditions. This increased probability is encompassed in the concept of priming of similar tasks. However, this is not the only possible mechanism that could induce transfer, there could be activating mechanisms, cascading mechanisms, or even large scale brain activities. But in order to understand the capacity of transfer, it is necessary to understand the concepts of analogies, creativity, and semantic distance.

Analogies have been defined as the process of mapping pairs of seemingly dissimilar objects that have comparable roles (Spellman & Holyoak, 2001). If the role of one item, in relation to another item, can be extracted from one pair, and this role is similarly found in the other pair of items, the two pairs can be said to be analogous. For example, when making an analogical comparison between the solar system and the atom, the electron-atom relationship can
be mapped to the planet-sun relationship. By extracting the relationship electron-revolves-around-atom, and superimposing it on planet and sun, we can see that planet revolves around sun is a sound statement, based on the Rutherford model of the atom, and the heliocentric model of the solar system. Thus, a valid analogy is created and, in fact, the relationship between the two can be abstracted to the relationship (revolve) and the roles (satellites, center) without the specific fillers from a particular domain (i.e., planet/electron, sun/atom). This abstraction has the potential to activate other, matching relationships, making analogies that include a “revolves” relation easier to process [include citation]. The more comprehensive the abstraction (i.e. containing the fewest contradictions and exceptions), the more enduring and salient it becomes, which would aid in solving analogically similar problems.

Creativity, on the other hand, is difficult to define because it is not confined by strict parameters. Creativity is such a vague and generic term that can loosely mean the capacity to create and not imitate. Creativity as Mayer (1999) defines it is “the novel generation fitted to the constraints of a particular task”. This study utilizes the concept of semantic distance in order to operationalize creativity. Semantics refers to the meanings of concepts and therefore semantic distance refers to the association between the meanings of words and the categories they overlap within. However, we use semantic distance in terms of analogies. Semantic distance governs the minimal scope of categorization an analogy can fall within, thus imposing those constraints defined by creativity. Less creative analogies can have both pairs such as nose:scent tongue:taste encompass a single domain, or within a single category: biological sensory/perception. If you can visualize semantic distance as a literal distance, neither pair needs to travel very “far” to resolve the analogy since the nose and tongue can typically be associated with each other in a single category as sensory organs. Thus, the closer a pair is semantically, the more associated
they are with each other. More creative analogies may also encompass a single domain, but this domain is not readily generalized to such an extent. Therefore, we often think of them as transgressing across domains. For example, nose:scent antenna:signal are in separate categories as one is biological and the other mechanical, but nose and antenna can both act as receptors. In this way, this is “further” in semantic distance because the association between the pair is much more general (where the receptor domain pretty much encompasses the sensory organ domain). Therefore you can visualize the constraints of more creative analogies as the requirement of travelling a certain associative distance before resolving the analogy. Resolution can be achieved by guidance of concepts already tied to the analogy. Nose and tongue already have many immediate relationships and shared features (what we might can alignable) while nose and antenna already have much less similarity. Thus, the “novel generation” in this case refers to the use of concepts and pairs with a weaker association (or “far” association).

The ability to categorize components of an analogy is critical to the analogical process itself. Green & Fugelsang (2006) demonstrated that subjects who performed analogies were also primed for words within the same category, indicating increased retrieval strength in connections relevant to the entire category found in near analogies. Additionally, this distinction can be seen neuroanatomically, in the difference in frontopolar activation. Green et. al. (2011) demonstrated that there is more frontopolar activation when generation of creative analogical solution to “far” analogical problems.

Furthermore, this distinction between near and far analogies essentially embodies the concept of abstraction. Abstraction in the analogical process removes the ties of the role to its fillers. On the other hand, as stated previously, the far analogies require a more general category that might encompass the relation found in the two analogies while the near analogies do not
need that level of abstraction. The nose must be abstracted from a sensory organ, to a receiver. Therefore, there are actually multiple instances of abstraction when performing a far analogy. The idea that differences of abstraction delineate differences in analogy is supported by a neuroanatomical study by Cristoff et. al. (2009). They showed that the lateral prefrontal cortex codes and organizes task relevant information necessary for abstraction, with stronger relative recruitment of the ventrolateral, dorsolateral, and rostrolateral prefrontal cortex in the cases of higher abstraction. Thus, different levels of abstraction recruited different levels of the prefrontal cortex. This is further support that there exists a difference between “near” and “far” analogies that can be manipulated in order to manipulate levels of creativity.

While it is speculated that creativity can be induced, each person already have prior levels of creativity. This creativity can be assessed in forms of fluid intelligence and categorical fluency. This can be assessed by a Raven’s Progressive Matrices Task and a Word Association Task respectively. The Raven’s Test would assess how well and quickly a person generates abstract associations that followed a set of rules. The Word Association Test would gauge how many associations a person can make within a category within a minute. A person with a high level of prior creativity would be able to make relational responses without the use of transfer. On both tasks, they are able to successfully access the weaker associations (or farther associations), in which this access is not dependent upon the completion of the first task.

Thus, we are trying to answer a problem based on transfer relative to creativity. Can relational processing be induced just by purely performing analogies, where only a relational mindset based on simple associations is induced? Or is it necessary to take that extra step and generate a relational mindset dependent on creativity, where relational mindset just refers to the involved activated circuits induced by varying the amount of analogical processing?
Method

I. Participants

54 participants were taken from the UCLA Psychology Department Subject Pool via an online registration system. Thus, most of the subjects were UCLA undergraduate students ranging from ages 18-22. Therefore, all subjects had at least a high school level of education. Most of the subjects were fluent English speakers with English as their first language. Many of the subjects had at least some psychology background.

All subjects signed up for the study through an online process that awards them credit after having completed the study. The credit (which translated to class grades) was the incentive for participation in the experiment, though it was not considered a variable within the study itself.

II. Materials

Performance of the study required a functioning computer with a keyboard and connection to the Internet in order to access the website, Qualtrics. The study was programmed upon Qualtrics and could have been potentially accessed by any person with both the access to the Internet and the URL generated by the site. The program was capable of consolidating information, such as keystrokes and reaction time, and exporting the information into a more user friendly format in which the data could be manipulated for analyses. Excel and SPSS were programs needed for tests of significance and interaction, as well as other analyses.

Near and Far analogies used in the study were taken from Green, Fugelsang, & Dunabar’s (2006) frontopolar- semantic distance study. The pictures used to measure relational mindset were from Tohill & Holyoak’s (2000) anxiety-performance study. Raven’s matrices used to measure fluid intelligence were obtained from Harcourt Assessment Inc.
III. Design

Subjects were randomly assigned to perform either near or far analogies. 28 subjects performed near analogies and 26 subjects performed far analogies. This study attempted to gauge the relative relational mindset of an individual after performing far vs. near analogies. The distinction between near and far analogies were made through the use of latent semantic analysis, which measured the amount of semantic distance within an analogy. On a relative scale, the analogies that were .5 or above on the semantic distance scale were deemed “far” analogies, while the analogies that were below .5 were deemed “near” analogies. The independent variable was the type of analogy (near or far) performed, with the degree of similarity of subject answers and number of similar answers used as a counterbalance. Similarity was judged by a hundred point Likert scale (Figure 5). The dependent variable was the amount of relational matches made by a subject on a visual task, after having performed either a near or far analogy task.

IV. Procedure

Subjects began the study when they were lead by an experimenter into a room with a sole Macintosh computer upon a desk and the Qualtrics program loaded. Subjects were instructed to sit at the computer and follow the instructions programmed on the survey. Before the subjects began, the experimenter would leave the room but left to option of quitting the experiment at any time or calling the experimenter for questions.

Each task was described on the screen by the program in full detail. The first task given to the subjects was a Ravens matrices task (Figure 1). This was a measure of the subject’s fluid intelligence in order to use as a counterbalance measure in case this variable interacted with any of the other parameters of the study, such as amount of relational matching. Afterwards, the subject was randomly placed into one of two groups: near or far analogies. Those placed in the
group with near analogies were given a series of 39 analogies deemed to relatively low semantic distance. Those placed in the group with far analogies were given a series of 39 analogies deemed to relatively high semantic distance. Each subject was first given a pair of words (A:B), and underneath these words there was an additional word, followed by a question mark (C:?). (Figure 2 & 3). Subjects were instructed to complete the blank in a manner that would resolve the analogy and align the pairs by typing in a text box. If the subject was still confused by the instructions, they were verbally informed that the pairs of words in an analogy would share the same relation. In most of the “near analogy” trials, subjects should have perceived the two relational pairs (A:B and C:D) to be in the same domain. In most of the “far analogy” trials, subjects should have perceived the two relational pairs (A:B and C:D) to be in different domains. After each trial, the subject was asked to give a similarity rating of their answer with the answer given (one possible correct answer) on a 100 point Likert scale. They were given a frame of reference in which a 100 was an exact match and a 0 was a complete opposite.

Once 39 trials were completed, the subject moved on to the next phase of the study. This phase involved matching highlighted objects on a top image with a corresponding object in a bottom image (Figure 5). The full image contained two scenes, one placed on top of another. The top image would have an object boxed with the remainder of the image unmarked. The bottom image would be completely unmarked. The highlighted object in the top image had a relational correspondence with only one object in the bottom image. The highlighted object in the top image also had a featural correspondence with only one object in the bottom image. The highlighted object in the top image was unrelated to the remaining objects in the bottom image. The subject was instructed to choose an object in the bottom image that “goes with” the highlighted object in the top image and type it in a text box. The subject’s choice would have
fallen into one of the aforementioned categories. The instructions were left purposefully vague because it was necessary to avoid suggesting any strategy to the subject or influence the subject in a manner that places them into a different mindset. Based on our definition of “mindset” any recently activation or processing could influence subsequent processing. Therefore, if a strategy was suggested, it would need to be processed and this would negatively affect results.

The subjects were finally asked to give demographic information such as age and language fluency, after which they received the credit used to compensate subject participation.

Figure 1. Raven’s matrix. This was used to test fluid intelligence.
**Figure 2.** Near analogy completion trial. Example of what is seen during a near analogy trial.

**Figure 3.** Far analogy completion trial. Example of what is seen during a far analogy trial.
Figure 4. 100 point Likert scale. The scale used to convey similarity of subject response to possible logged answer.

Figure 5. Matching trial. Pairs of images with a highlighted object seen during the matching task.
Results

The analysis of the data primarily focused on factors that would result in a difference in the amount of relational responses. In the analogical completion task, subjects that performed “far” analogies gave a significantly higher proportion of relational responses in the relational matching task (M= .6808, SD= .188) than those that performed “near” analogies (M= .4964, SD= .235), with t= -3.170, df= 2, p= .003. However, this result does not take into account the effects from the Raven’s Progressive Matrices scores, similarity scores, or reaction time. For this, the differences of the proportion of relational responses was analyzed using a 2 x 2 x 2 x 2 (group [near, far] x reaction time [near, far] x Raven’s score [near, far] x similarity score [near, far]) Analysis of Variance (ANOVA) was performed. This resulted in a main effect of group, F(1,53) = 8.475, p = .005. The resulting marginal means (Figure 6) were not much different than the means of the t-test: near (M=.464, SE= .050), far (M=.715, SE= .053). The main effects from the other variables were insignificant. This eliminated the interpretations that other factors could be the cause of the differences found within the group.

It was assumed in this experiment that those with higher fluid intelligence would be able to give more relational responses. Therefore, we performed a median split of the data of those with higher Raven’s scores and those with lower Raven’s scores in order to assess whether this prediction was reasonable. Subjects with higher Raven’s scores gave a significantly higher proportion of relational responses in the relational matching task (M= .6556, SD= .227) than those with lower Raven’s scores (M= .5148, SD= .216), with t= -2.330, df= 2, p= .024. This supported the assumption that without the analogical task, those that had a higher fluid intelligence would already give relational responses. This validated the need for accounting for this factor in the previous analyses. Furthermore, when accounting for the median split of the
Raven’s test, the effects by group remained. A 2 x 2 (group [near, far] x Raven’s score [high, low]) Analysis of Variance (ANOVA) resulted in a significant group main effects: F(1,53) = 8.891, p = .004, with the “far” group remaining above the near group (Figure 7). This further supported the idea that the performance of “far” analogies would result in more relational responses regardless of fluid intelligence. An interesting trend was found in the difference between groups was more pronounced in the subjects that had a lower Raven’s score than those with a higher Raven’s score (p= .086).

These results could be compared to a previous experiment with the same design that involved the validation of “near” or “far” analogies instead of completion. Analysis of the differences in proportion of relational response utilized a 2 x 2 (group [near, far] x experiment [completion, validation]) Analysis of Variance (ANOVA). This resulted in a significant group x experiment effects, F(1,137) = 5.438, p =.021 (Figure 8). With combined near and far samples, the main effect of both group and experiment were not significant. This indicated that there was a difference between the experiments and that completion yielded different proportions of relational responses between the two groups.
Figure 6. Comparison of proportion of relational responses in Near and Far groups while accounting for Similarity scores, Raven’s scores, and reaction time.
Figure 7. Comparison of proportion of relational responses in Near and Far groups crossed with High and Low Raven’s scores, blue = low scores, green = high scores.
Figure 8. Comparison of proportion of relational responses in analogical validation vs analogical completion tasks crossed with Near and Far groups, blue = Near, green = Far

Discussion

The results of the experiment suggest that there is an additional component above analogical reasoning that induces a certain degree of creativity. Creativity in this context is operationalized to pertain to relational transfer, in which the underlying strategy used in one task (verbal) was mirrored in a subsequent task (pictoral) in which both required mapping of components between concepts. Subjects that performed the verbal completion analogies with more semantic distance (which require more creativity) selected a relational item in the following mapping task significantly more than subjects that performed verbal completion.
analogies with less semantic distance. This effect was seen above and beyond fluid intelligence, which was measured using Raven’s Progressive Matrices and accounted to the amount of creativity a subject had prior to performing analogies. This meant that performing “far” analogies enhanced the transfer of relational strategy of both those that had reduced creativity and those that were already considerably creative. Prior creativity was a factor because regardless of performing analogies, these people would already have access to a wider range of associations. Thus, induced creativity promoted a degree of transfer greater than most of the internal creativity of most subjects.

However, the interpretation of the results is limited to the constraints of the study. While creativity was operationalized in terms of semantic distance, this doesn’t completely encompass all categories of creativity. Creativity in terms of spatial problems or other domains or instances of problem solving haven’t been confirmed to be capable of transfer. Recall that Mayer (1999) defined creativity as novel generation fitted to the constraints of a task. By this definition, creativity is extremely broad. This is because novel generation is dependent on the subject and the specific instance. When encountering a problem, the initial generated solution by any given individual could be considered creative. Therefore, as long as there are new tasks, there are going to be novel generations. Regarding this study, creativity was a continuous property that varied along a gradient. This is because word associations reflect the concepts stored within the confounds of the many networks within the brain, and these concepts have different strengths of association based on a number of factors. These factors include the amount of exposure, the salience of each item, and the number of related components within a concept. For example, a dog is related to a cat as both words and concepts. A dog shares features such as legs, fur, and a tail with the cat, and both fall under a single category (domestic animal). This can be contrasted
with concepts dog and table. Both are objects with legs, but the fur and tail of the dog don’t associate with components of the concept of table. Therefore, it is more creative to generate an analogy that utilizes the dog-table relationship (than the dog-cat relationship) because it is both far less common and contains fewer connections.

The other forms of creativity can be found in many higher order cognitive processes other than analogical thinking such as decision making and problem solving (even though solving an analogy is a type of problem). Creativity in these processes is more difficult to define and vary less upon a single gradient. This is because there are multiple cognitive components in a task such as problem solving, and the search space must be limited. The problem of finding the shortest route to a specific location could have a variety of different methods of reaching the solution which can encompass different domains such as utilizing a mental representation of a map, or by using mathematics in which distance is an abstract concept rather than a visual estimation. These approaches can’t be placed on a gradient because they are of entirely different domains and don’t contain enough corresponding elements to be compared. It would be necessary to limit to a single search space or domain, but even then, we wouldn’t be certain how to generate a continuous scale for certain aspects because there are no prior associations. Every solution generated is novel. This problem could potentially be avoided by training subjects for certain strategies. However, there still remains the problem of generating a defined scale of creativity specified to the task.

While there would be many difficulties to overcome in developing studies that look at other aspects of creativity, there are many aspects of this study that could be improved. When looking at the data, there were some peculiarities and nuances that indicated that there was some subject bias or consistent subject confusion. Some of the “far” analogy trials had little variance,
but for the incorrect answer. While it is true that a “far” analogy allows for a wider variety of answers, these particular responses did not align particularly well. Furthermore, the pictures used were taken from a past experiment (Tohill & Holyoak, 2000), but some of the items were indecipherable and made little sense. For example, in one of the images, a person was inside a house cooking a chicken, but this building was situated in front of a baseball game in a fashion that looked awkward. In other images, there were multiple items that could be referred by the same name, but only one specific item could be a relational match or featural match. An example of this could be found in the image with a repair man and a machine. The machine contained a part that looked like an arm. However, there was also a box containing spare arms; thus a subject that responded “robot arm” could be referring to one of two items. Therefore, it is necessary to alter the task in a manner that removes this confusion such as allowing the subject to click anywhere on the screen and that position is logged and can be referenced for the selected item. It may even be necessary to generate new pairs of images.

The induction of relational transfer (or more broadly, creativity) has profound implications in terms of learning as well as society as a whole. Many limitations of problem solving and understanding lie in the inability to access all the possible associations of a particular concept. This difference in activation has an evolutionary advantage. Stronger associations are those that have received relatively more exposure and these stronger associations are preferentially activated. Because a person will encounter those associations more often, it is advantageous to make the association more automatic than weaker associations, which are encountered less often. Even though decisions that involve life and death have considerably decreased as society progresses, these processes are essential to function in society as well. A person needs to be able to know how to act in a social situation and slower processing of a given
socially acceptable action may be perceived as abnormal. However, this places a constraint on creativity, since novel generation depends on the activation of a larger variety of associations, instead of being tied to the more prominent connections. A solution to this problem would need to incorporate aspects of both processing of more relevant information as well as leave the potential for access to less relevant information. The results from this study demonstrate that it is possible to induce a type of creativity that transgresses the task domain. While this is far from achieving simultaneous activation of both types of processes, it is possible to increase creativity for a period of time when needed. Therefore, in situations where creativity becomes necessary, a person could actually increase their capacity to access those weaker associations. And though this study could only suggest this activation in one specific domain, if this effect could be extended to other areas of cognition, this could aid in learning dependent of the efficiency of transfer. The time it takes for a person to understand a concept or problem depends on their ability to activate all the relevant aspects and connected elements to the concept or problem at hand. Under certain conditions, it is sometimes easier or more difficult because a critical component was left inactivated. Recall the problem of finding the shortest path. A person could understand all the nuances of the topography of a map (activated when given the task of generating the shortest route), but if they don’t remember that the shortest distance between two points is a line, they wouldn’t think to search for a path with the fewest lines straying from the single line that connects the start and destination.

Further research would involve the assessment of the brain regions involved in the process. From the results we are unable to ascertain the mechanism of transfer as it progresses through the brain. Do the brain regions required in analogical completion of far analogies activate when successfully making a relational response in the picture task? Are the regions
activated specific to far analogies such as certain frontopolar regions found by Green (2006) when semantic distance was varied? Or do these regions activate a subsequent cascade that induces a relational mindset. One hypothesis is that the regions needed for semantic distance are primed by activation and therefore are easier to activate on a task that immediately follows the analogy completion. These primed regions allow for access of more abstract associations and a larger array of connections, such as the many roles an object may play. Another hypothesis is that by performing “far” analogies, there is a network switch that is activated that changes the way information is processed, but this processing does exist solely in a corresponding area of activation; it may not even be a single location or network. Because a single change can propagate many other changes in the brain, different activations can activate cognitive pathways that lead to an overall increase in creativity. These questions highlight the reciprocal nature of cognitive science and neuroscience; by discovering the networks and pathways involved we can further construct ideas pertaining to the nature of transfer and creativity, which in turn begets questions about connectivity and neural mechanism.
References


Analogue Reasoning with Fractions and Decimals

Elnaz Khalili

Abstract

In our previous study we found that college students were significantly more accurate in finding a relation between a picture and a rational number if the number was presented in a fractional format. We concluded that this difference in accuracy is due to the relational structure of fractions. One alternative explanation for these findings was that subjects were able to do a one-to-one mapping between the two parts of a picture and the two parts (numerator, denominator) of a fraction. In order to rule out this explanation, we conducted two new experiments. In the first experiment, subjects (75 undergraduate students) were presented with 3 types of numbers: simple fractions (one-to-one mapping between the picture and the fraction), hard fractions (not-one-to-one mapping), and decimals. Our results showed that subjects were still significantly more accurate in working with fractions than decimals, even if the relation between the fraction and the picture was not one to one ($F (1, 72) = 10.02, p=0.002$). Comparing subjects’ time reactions for these 3 types of data, however, showed that subjects spent a considerably higher amount of time for working with hard fractions. In order to control for the possible confounding effect of time reaction on level of accuracy, we conducted a second experiment, in which subjects were not anymore under a time pressure. Results from experiment 2 supported our initial findings that students are more accurate in performing relational analogies when working with fractions (simple fractions and decimals: $F (1, 63) = 20.30, p < 0.001$; hard fractions and decimals: $F (1, 63) = 6.802, p = 0.011$). In this experiment the difference between time reactions for hard fractions and decimals was not significant anymore ($F (1, 63) = 0.012 p = 0.914$).

Key words: Analogue reasoning, fractions, decimals
One of important abilities of human cognition is that it understands and works with numbers and mathematical equations. One question cognitive scientists try to answer in this area is what exactly the psychological foundation of our mathematical cognition is. In order to answer this question a great number of studies, mainly on children and college students, have been conducted. Some of these studies showed that human children have the ability to estimate quantities and to reason arithmetically with these estimates even before the time they start talking (Gelman & Gallistel, 1978). Despite this surprising initial ability, it has been well known that school-aged children typically experience a very hard time to learn how to use decimals and fractions in their mathematical calculations. One example of such problem is that children tend to inappropriately extend some properties of integers to decimals. In their study on fifth and sixth graders’ mathematical abilities, Siegler and Alibali (2005) observed that a majority of students in their experiment claimed that 0.274 is larger than 0.83. These children had assumed that, as it is the case for integers, number of digits in a decimal directly relates to its magnitude. A similar problem has also been observed when children make judgments about the magnitude of fractions. Carol L. Smith et al. (2005) asked a group of elementary school students to compare two fractions, 1/75 and 1/65. Results of this study showed that majority of these students believed 1/65 is the bigger number, indicating that they just compared the magnitude of the integers in the denominators without caring about the actual role of these numbers in the original fractions. Because students in school first learn about integers, it is very hard for them to understand the notion of infinite divisibility of a number (Smith et al., 2005). Problems in understanding and working with rational numbers are not just limited to children. Studies have shown that working with fractions also pose extra processing burden for adults. Several explanations for these difficulties have been proposed by the cognitive scientists. One idea is that
when decimals and fractions are added to our system of numbers, the discrete ordering of integers is no longer valid. As a result, we cannot specify the exact next number in a sequence of numbers because there are an infinite number of fractions and decimals between each two numbers. Another possible reason for difficulty in working with rational numbers is that for applying fractions in arithmetic calculations most of the times we need to change their a/b format to a decimal representation. For most fractions this conversion takes a significant amount of time, and also for some fractions, such as 2/3, there is no complete decimal representation. Considering this advantage of decimals over fractions in calculations, it may seem that we do not have any basic need for fractions in mathematic. In our previous study on this issue, we showed that college students were significantly more accurate in extracting a relation between a picture and a magnitude if it was in the form of a fraction. In that study we concluded that this advantage of fractions over decimals is due to the relational structure of fractions. One proposed alternative explanation for the results we obtained in this study is that since we only used the simplest possible representation for each fractional number, subjects were able to do a one-to-one mapping between the two parts of each picture and the numerator and denominator of the fraction presented with it. In our two new studies we examined this hypothesis. We replicated the design of the original study, but this time we only used discrete pictures. A third level, called hard fractions, was also added to the number type variable in order to examine the one-to-one mapping hypothesis. We defined a hard fraction as the fraction whose numerator and denominator cannot be mapped one-to-one to the two parts of a picture. The results from the follow up study demonstrated that the advantage of fractions over decimals for extracting a relation between a picture and a magnitude is also significant for hard fractions. When looking at reaction time measurements, however, it was found that subjects spent a significantly higher
amount of time for working on hard fractions. In order to control for this confound variable, in our second study we instructed the subjects in the all three groups to take as much time as they needed to work on the relationships. The reaction times for the three number type groups were not anymore significantly different in this new study, while the same significant difference in accuracy for working with simple and hard fractions was obtained again.

Experiment 1

Methods

Participants

75 undergraduate students at University of California, Los Angeles (53 females, Mage = 20.4) participated in this study.

Design

This study was designed as a 2×3 experiment. Our first independent variable was the relation type, with 2 levels: part-part ratio and part-whole ratio. This variable was manipulated within subjects. The second independent variable was the number type, manipulated between subjects, with 3 levels: simple fractions, hard (not one-to-one) fractions, and decimals. For the pictures in which the common factor of magnitudes of the two parts was 1 (like 3 circles and 2 crosses), we made the hard fractions by multiplying the two numbers with 2 or 3 (like 4/6). For those pictures in which the two magnitudes had a common factor greater than 1 (like 3 circles and 6 crosses), we made the hard fractions by dividing the two numbers by 2 or 3 (like 1/2). For each relation 24 items were used (a total of 48 trials).

Materials

For each question a discrete source picture was matched with either a fraction (simple or hard) or a decimal. This number represented either a part-part or part-whole ratio within the
source picture. For example, if the picture consisted of 3 circles and 2 crosses, in the fraction group the matched number would be 2/3 (simple part-part ratio), or 2/5 (simple part-whole ratio), or 4/6 (non-simple part-part ratio), or 4/10 (non-simple part-whole ratio). In the decimal group, this particular picture would be matched with 0.67. Similar pictures and rational numbers were used for the test trials.

Procedure

In the beginning of the study, subjects were informed that two different types of relations between the pictures and matched numbers existed. For the part-part relationship, subjects were presented with a picture with 1 circle and 2 crosses. For the fractions condition this was explained as “1/2 amount of circles per amount of crosses;” for the decimals condition it was explained as “.50 amount of circles per amount of crosses.” The part-whole ratio was represented with a picture of 2 circles and 3 crosses. For the fractions condition this was explained as “2/5 of the total is the amount of circles;” for the decimal condition it was explained as “.40 of the total is the amount of circles.” In each test trial, subjects were first presented with a source picture and its matched number. In the second part of the same trial, another picture along with two numbers (in the same format as the first number) was shown. Subjects were instructed to choose the number which represented the same relation between the picture’s parts as the relation showed by the number in the first part. They were also told to try to go as quickly and accurately as possible. After completing 12 practice trials with feedback, subjects continued on to the test trials and were given feedback throughout the task.

Results

Accuracy and mean response time for correct answers were subjected to a mixed factors ANOVA test. Figure 1 depicts the mean percent accuracy for different number types and also
pictorial relationships. A significant interaction was found between relation type and number type, $F(2, 72) = 3.182, p = 0.047$. There was also a significant main effect of number type, $F(2, 72) = 27.785, p < 0.001$, and relation type, $F(1, 72) = 8.325, p = 0.005$. The statistical results also showed that accuracy for simple (one to one) Fractions was significantly higher than accuracy for decimals (95% vs. 65%, $F(1, 72) = 55.24, p < 0.001$), and accuracy for hard Fractions (95% vs. 78%, $F(1, 72) = 17.56, p < 0.001$). Accuracy for hard Fractions was also significantly higher than accuracy for decimals (78% vs. 65%, $F(1, 72) = 10.02, p=0.002$).

Figure 2 illustrates the mean reaction time for the 3 different number groups. Response times did not show significant effects for interaction between relation type and number type, $F(2, 72) = 1.63, p = .204$, main effect of relation type, $F(1, 72) = 3.003, p = 0.087$, and main effect of number type, $F(1, 72) = 1.78, p = 0.175$. Planned comparisons between the different number types also showed no significant effects (simple vs. hard fraction: 8.69 s vs. 26.26 s, $F(1, 72) = 3.20, p = .078$; simple fraction vs. decimals: 8.69 s vs. $F(1, 72) = 1.79, p = .175$), hard fraction vs. decimals: 26.26 s vs. 12.30 $F(1, 72) = 2.08, p = .154$). The important finding here is that subjects in the hard fractions condition spent considerably a higher amount of time than either of the other two number types (simple fractions and decimals).

**Discussion**

Results of this experiment strongly supported what we had found in the previous study: for extracting a relationship between a picture and a magnitude, college students are significantly more accurate when the magnitude is presented in a fractional format than when it is a decimal. Our new results also showed that this advantage of fractional format is also true for the fractions whose numerators and denominators do not have a one-to-one mapping with the parts of the picture. Nevertheless, evaluating the time reactions showed that subjects also spend a noticeably
higher amount of time for working with hard fractions than for either decimals or simple fractions. In order to control for the possible confounding effect of this difference in time reactions on percentages of accuracy, we conducted a second experiment, in which subjects were not under the time pressure. We expected that subjects would spend a higher amount of time for answering questions with decimals when they are not anymore under a time pressure.

Experiment 2

Methods

Participants

66 undergraduate students from University of California, Los Angeles (53 females, Mage=20.6) participated in the second experiment. They were randomly assigned in equal numbers to the three number conditions (simple fractions, hard fractions, decimals).

Design

The design and procedure of this new experiment were exact replications of the experiment 1, but subjects were not under a time pressure. They were explicitly ordered to spend as much time as they would need to answer the questions.

Results

Like the first experiment, accuracy and mean response time for correct answers were subjected to a mixed factors ANOVA test. Figure 3 illustrates the mean percent accuracy for different number types (simple fractions, hard fractions, and decimals) and also pictorial relationships (part-part ratio, part-whole ratio). No interaction was found between relation type and number type, $F(2, 63) = .682, p = .509$. There was a significant effect of relation type, $F(1, 63) = 4.109, p = .047$, and a significant effect of number type, $F(2, 63) = 10.234, p < 0.001$. Planned comparisons showed that simple fractions had higher accuracy than decimals (94% vs.
73%, $F(1, 63) = 20.30, p < 0.001$) and hard fractions (no one-to-one mapping) also had significantly higher accuracy than decimals (85% vs. 73%, $F(1, 63) = 6.802, p = 0.011$). There was no significant difference between simple fractions compared to hard fractions (94% vs. 85%, $F(1, 63) = 3.60, p = .062$).

Figure 4 depicts the mean reaction times for the 3 different number groups of the second experiment (no time pressure). We found no interaction effects, $F(2, 63) = 2.30, p = .109$, and also no main effects for relation type (part-part vs. part-whole), $F(1, 63) = .952, p = .333$. However, a significant main effect for number type was found, $F(2, 63) = 7.59, p = 0.001$.

Reaction times for simple fractions were significantly lower than hard fractions (11.06 s vs. 20.17 s $F(1, 63) = 11.02, p = 0.002$) and also decimals (11.06 s vs. 19.46 s, $F(1, 63) = 11.75, p = 0.001$). The most important result in this new experiment was that no significant difference between reaction times for hard fractions and decimals was found (20.17 s vs. 19.47 s, $F(1, 63) = 0.012, p = .914$).

Discussion

In experiment 2, subjects spent a fairly equal amount of times for working with the three types of numbers (simple fractions, hard fractions, and decimals). Results for percentage of accuracy were similar to those obtained in the first experiment: subjects were significantly more accurate in working with fractions (both simple and hard) than when working with decimals. The difference between the two types of fraction, however, was not significant anymore.

In general, the results obtained in these two new experiments support our initial hypothesis that, due to their relational formats, fractions are a better number type (when comparing to decimals) in performing analogical reasoning between pictures and numerical magnitudes. This advantage
for fractions is still true even if there is not a one-to-one mapping between the parts of a picture and parts of a fraction (numerator and denominator).
References


**Figure 1.** Percent accuracy for 3 types of numbers (one-to-one fractions, hard or NOTO fractions, and decimals) in experiment 1.

**Figure 2.** Response times for simple (OTO) fractions, hard (NOTO) fractions, and decimals in experiment 1.
Figure 3. Proportion correct for 3 types of numbers (one-to-one fractions, hard or NOTO fractions, and decimals) in experiment 2 (no time pressure).

Figure 4. Response times for simple (OTO) fractions, hard (NOTO) fractions, and decimals in experiment 2 (no time pressure).
Perceiving the Animacy and Interactivity of Point-light Biological Motion

Frederic Chang

Point-light animations representing various forms of biological motion are an established tool for studying human visual perception. For example, dots can be animated to look like a person walking or two people dancing together. Humans seem to have high sensitivity to these animated motion cues due to them being able to quickly and spontaneously perceive moving point-lights attached to joints as animate. However, only a few studies have examined the specific processes that drive our judgment and perception of animacy and interactivity (Thurman & Lu, 2013). It is important to study these visual processes that are vital to understanding the visual world and allowing adaptive behavior.

In a recent study done by Thurman and Lu (2013), the congruency between intrinsic movements (ex. limb movements) and extrinsic movements (movement of the centroid of point-light figures) was manipulated in relation to human perception of animacy. The results indicated that recognition of animacy was significantly increased by retaining congruency between intrinsic and extrinsic motion (Thurman & Lu, 2013). Thus, it was further hypothesized that the visual sensitivity to congruency between intrinsic and extrinsic motion is due to prior knowledge of the causal relationship between intrinsic motion and extrinsic motion typical to biological creatures in natural settings (Thurman & Lu, 2013). This study was unique because most previous studies of biological motion and animacy have focused on either extrinsic motion or intrinsic motion in isolation, without considering the interactive influence of these two sources of information.

In our experiments, we first examined whether or not observers spontaneously perceive animacy and meaningful interaction when taking away spatial structure of point-light actors.
(they do not appear biological or human-like anymore) but retaining local biological kinematics. This was done by applying random spatial scrambling to the starting positions of the points on each trial. In effect, scrambled animations immediately appear as a blob or a cloud of dots instead of a human figure due to the destruction of global spatial cues. In addition, we examined the degree to which maintaining congruency between intrinsic local joint movements and extrinsic global body movements plays a role in a task discriminating interactivity of salsa dancing point-light animations (Experiment 2), and a task rating the degree of interactivity of salsa dancers.

**STUDY 1**

By taking away spatial structure via scrambling the dots in point-light animations involving two actors, we sought to investigate the degree at which animacy and meaningful interactions can still be perceived. That is, if humans are still able to perceive animacy and human interaction from figures that no longer appear human-like or biological, then they should be utilizing mechanisms of perception and judgment that are based on the characteristics of motion. Another variable that was manipulated for a few subjects was that extrinsic motion and intrinsic motion were made incongruent with each other for all of the animations they viewed.

**Method**

**Participants**

Participants were 47 students from the University of California, Los Angeles who signed up for the experiment for credit towards course requirements or extra credit for classes they are enrolled in. They were all naïve to the concept of point-light biological motion, and are also unfamiliar with point-light animations.

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Design and Procedure

All of the participants viewed 8 different spatially scrambled point-light sequences in pseudo-random order, counterbalanced using Latin square to account for the practice effect. The 8 sequences, each involving 2 actors, were: shaking hands, playing tug of war, holding hands and swinging them while walking, throwing and catching an object, walking and giving high-five, pulling somebody out of a chair, threatening to punch a person who recoils, and salsa dancing.

After watching one of the eight animations of the screen, participants were simply instructed to write down on a piece of paper a description of what they saw. For each participant, this process was repeated for each of the eight animations.

37 out of 47 participants viewed spatially scrambled sequences with the intrinsic and extrinsic motion congruent with each other, while the 10 remaining participants viewed the sequences with incongruent intrinsic and extrinsic motion. The incongruency was caused by reversing the time course of the extrinsic motion only; doing this maintained the correlation between joints and the correlation of the global movements, but they were not correlated with each other.

During transcoding of their responses, we paid specific attention to the nouns and verbs used to describe the scrambled sequences. Nouns were categorized as physical (ex. dots, blob, thing) or animate (ex. people, creature) and verbs were categorized as physical (ex. move, shift, bounce), animate (ex. dance, walk, hold) or interactive (ex. dance together).
Results

Figure 1. Word clouds: Frequency of words subjects used to describe interactions

In figure 1, the bigger a word is, the more frequently it was used by subjects to describe the specific scrambled sequence. These words were also used to assess whether or not subjects used physical (ex. figure, move) or animate and interactive words (ex. dance, high-five). Note that these word clouds only created from the results of the 37 subjects that participated in the condition where intrinsic and extrinsic motion were congruent.
Figure 2. Proportion of subjects who used animate and/or interactive verbs

For the congruent intrinsic/extrinsic motion condition, the scrambled salsa dance sequence invoked the most responses with action and/or interactive (these 2 categories were grouped together) verbs. Following that was the high-five animation, and so on. A similar trend was seen in the incongruent condition, except all proportions were lower, except for the throwing ball and hand swinging animations. The mean proportion for the congruent condition was 0.58, with a standard deviation of 0.16, whereas the mean for the incongruent condition was significantly lower at 0.36 with a standard deviation of 0.14, indicating that there is a main effect of congruency: t(7) = 3.37, p<0.05 (p=0.12). This implies that naïve observers were more likely to attribute animacy and interactivity to scrambled interactive sequences that maintained the fundamental constraint of congruency between extrinsic and intrinsic body motion.
Figure 3. Tracing the mean horizontal extrinsic motion (x-axis) of each actor in each sequence across time (y-axis)

Figure 4. Mean amount of horizontal extrinsic motion of each sequence (in the order shown by figure 3)

Figure 3 was generated by tracing horizontal extrinsic movement over time, whereas figure 4 compiles the average horizontal extrinsic motion of each sequence. The sequences where subjects primarily used animate and interactive words also corresponded to higher mean extrinsic horizontal motion. For instance, salsa dancing had the most horizontal extrinsic motion, and was also rated most frequently as animate and/or interactive. Sequences with low amounts of extrinsic motion (e.g. throwing a ball, holding hands and walking toward observer) were far less likely to be associated with animate verbs. Therefore we used salsa dance animations as a
baseline to further explore which specific visual cues are used to judge interactivity between two interacting agents.

Something worth noting is that the throwing a ball animation and walking while holding hands animation contained very little extrinsic motion, as shown by figures 3 and 4. This may account for why in figure 2 the congruent and incongruent conditions for these two sequences were so close in proportion of subjects describing them as animate or interactive. We believe that making the extrinsic and intrinsic motion incongruent did not really change the results between these two conditions, because there was little extrinsic motion in the sequences anyways, so most of the visual analysis was based solely on intrinsic limb movements.

**STUDY 2**

In the study done by Thurman and Lu (2013) as mentioned before, the results showed that human recognition of animacy is significantly increased by retaining congruency between intrinsic and extrinsic motion. In our second experiment, we were interested in whether or not or how much this constraint contributes to the perception of interaction between two agents. In an attempt to understand whether observers relied on local spatio-temporal correlation among joints (intrinsic motion) or global position changes (extrinsic motion), both of the individual congruencies of intrinsic motion and extrinsic motion were manipulated.

**Method**

**Participants**

29 University of California, Los Angeles students signed up to receive course credit.

**Design and Procedure**

A 2x2x2 factorial design was utilized and analyzed with repeated measures ANOVA. There were three factors for the sequences of two salsa dancers: spatial scrambling (intact vs.
scrambled), extrinsic motion congruency (congruent vs. incongruent), and intrinsic motion congruency (congruent vs. incongruent).

The task given to participants was 2-interval forced choice, where one interval had dancing partners (target interval) and the other had non-partners (distractor interval). Participants were instructed to pick which interval had interaction, in terms of either: both intrinsic and extrinsic motion were congruent, only intrinsic motion was congruent, only the extrinsic motion was congruent, or neither were congruent (true distractor). These conditions were tested with spatially scrambled or spatially intact salsa dancers.

Results

Figure 5. Proportion of interactions identified for congruent or incongruent extrinsic and/or intrinsic motion.

First of all there was a significant main effect in spatially scrambling the dancers $F(1,28) = 39.3$, $p<0.0001$; accuracy was significantly higher for the spatially intact condition. This is
likely attributed to the general benefit of maintaining structural cues which aid in the integration of moving points into a coherent global percept of human action.

There was also a significant main effect in extrinsic motion congruency $F(1,28) = 50.9$, $p<0.0001$ as well as a significant main effect in intrinsic motion congruency $F(1,28) = 46.02$, $p<0.0001$.

For the spatially intact condition, congruent intrinsic or extrinsic motion produced significantly higher accuracy of perceiving interaction than either of the incongruent motion counterparts. However, since there were no significant interactions ($p > 0.05$), this implies that a similar underlying mechanism is involved with processing intrinsic and extrinsic movements in spatially intact and scrambled actors, albeit with a general improvement as a result of including spatial structure, perhaps by increasing the efficiency with which the basic level cues are analyzed and integrated for perception of animacy and interactivity.

Interestingly, for the spatially scrambled condition, the only condition that was above chance was having both the extrinsic and intrinsic motion intact; the three other conditions were not significantly different from chance (one sample t-test shows $p > 0.05$) as shown in figure 5. This implies that in the absence of global spatial structure, as long as there is congruency between extrinsic and intrinsic motion, (salsa dance) interactions can be perceived. Therefore, there may exist a basic visual filter that tunes to the causal relation between intrinsic and extrinsic motion, and when this constraint is violated perception of animacy (Thurman & Lu, 2013) and interactivity fail completely in the absence of helpful spatial form cues.

**STUDY 3**

As implicated by the results of experiment 2, in experiment 3 we were interested in checking for the prerequisite of having congruency between intrinsic and extrinsic motion before
being able to perceive meaningful interaction. If this were true, based on the findings of Thurman and Lu (2013), then perhaps interacting agents must also first be seen as animate before they can be perceived as interactive. Instead of measuring discrimination ability, we measured subjective ratings of interactivity for spatially scrambled salsa dancers that either maintained or did not maintain congruency of extrinsic and intrinsic motion.

Method

Participants

11 University of California, Los Angeles students who registered and participated in the experiment in exchange for course credit.

Design and Procedure

A 2x2 factorial design was used, later analyzed by repeated measures ANOVA. There were 2 factors: interacting or not (partnered vs. not partnered salsa dancers), which was akin to the target and distractor intervals in the previous experiment, and congruency between intrinsic and extrinsic motion (congruent vs. incongruent). Like experiment 1, the congruency between intrinsic motion and extrinsic motion was broken by reversing the timecourse of extrinsic motion. Importantly, this manipulation ensured that extrinsic motion between the agents had the same correlation over the time course of the animation, and intrinsic joint movements also retained the same level of correlation between the agents. If observers could use either cue in isolation, then interactivity should appear the same between the two agents.

For the task subjects were asked to rate how interactive, on a scale of 1-5 (with 1=least and 5=most interactive), the scrambled animation of salsa dancers appeared. Each trial had spatially scrambled dancers.
Results

Figure 6. Rating of interactivity of scrambled salsa dancers with congruent or incongruent intrinsic/extrinsic motion, and partnered (targets) or un-partnered (distractor) movements.

The ANOVA results showed a main effect of interacting (partnered or not-partnered) dancers $F(1,10) = 8.6, p = 0.015$. Partnered dancers showed higher mean interaction ratings than non-partnered dancers, particularly when intrinsic and extrinsic motion were congruent.

There was also a main effect of congruency of intrinsic and extrinsic motion $F(1,10) = 82.2, p<0.0001$. Congruent intrinsic and extrinsic motion showed higher mean interaction ratings than incongruent.

Additionally, there was a significant interaction between the partnered relationship between the agents and congruency of intrinsic and extrinsic motion $F(1,10) = 18.17, p<0.002$; when dancers were partnered and the motion was congruent, the interaction ratings were significantly higher than for the rest of the conditions, confirmed by paired-samples t-test comparing conditions (all $p<0.002$). Interestingly, even the non-partnered plus congruent
intrinsic/extrinsic motion condition had significantly higher interaction ratings than salsa dancers who were truly partnered but were incongruent between their intrinsic motion and extrinsic motion. Amazingly, this implies that the constraint of intrinsic and extrinsic motion congruency is actually more potent for perceived interactivity than having correlated joint and body movements. This further highlights the interactive influence of both intrinsic and extrinsic motion in the perception of animacy and interactivity between spatially scrambled point-light human agents.

Discussion

Experiment 1 showed that higher mean horizontal extrinsic motion in scrambled point-light animations correlated with higher proportions of subjects judging the animations as being animate and interactive. Thus, salsa dancing animations, which had the highest values for both variables, were chosen as the template animation for further studying motion perception. Also, there was a main effect in the congruency between intrinsic and extrinsic motion, in that in the congruent condition, sequences were viewed as more animate and interactive. The throwing a ball animation and walking while holding hands animations, which contained very little extrinsic motion, showed very close results between the congruent and incongruent intrinsic/extrinsic motion conditions. This was likely due to the fact that since there was so little extrinsic motion in the sequences, most of the visual analysis was based on the intrinsic limb movements, and so inverting the timecourse of their extrinsic motion did not produce a significant effect.

In study 2, there was a main effect in spatially scrambling the dancers, whereas interaction was more likely recognized in the spatially intact condition. This probably due to the structural cues helping to integrate moving dots into a coherent global percept of human action. There were also significant main effects of both extrinsic motion congruency and intrinsic
motion congruency. Keeping either intrinsic or extrinsic motion congruent resulted in greater accuracy for recognizing interaction than for their incongruent counterparts. On the other hand, there were no significant interactions, which suggests the involvement of a simple underlying mechanism involved with processing intrinsic and extrinsic movements. Another significant result of study 2 was that in the spatially scrambled condition, the only condition that was above chance was when both the extrinsic and intrinsic motion was intact; all the other conditions were not significantly different from chance, implying that when the causal relation between intrinsic and extrinsic motion is violated, animacy (Thurman & Lu, 2013) and interactivity cannot be perceived when there are no helpful spatial form cues.

Experiment 3 showed a main effect of interacting (partnered or not-partnered) dancers where partnered salsa dancers showed higher interaction ratings than non-partnered dancers. This effect was more pronounced when intrinsic and extrinsic motion were congruent. There was also a main effect of congruency of intrinsic and extrinsic motion, where the congruent condition showed higher mean interaction ratings than the incongruent condition. In addition, there was a significant interaction between the partnered relationship between dancers and congruency of intrinsic/extrinsic motion; interaction ratings were much higher than for all of the other conditions when dancers were partnered and intrinsic/extrinsic motion were congruent. Surprisingly, the condition with partnered dancers and incongruent extrinsic/intrinsic motion produced lower interaction ratings than the condition where dancers were not-partnered but extrinsic/intrinsic motion were congruent.

It was interesting to see from experiment 1 that naïve observers were spontaneously able to attribute animacy and interactivity to scrambled animations that did not immediately appear human-like, but solely retained low level joint kinematics of human actors. Although observers
appeared to be influenced most by extrinsic body translation, the intrinsic joint movements must also be congruent with extrinsic motion for interaction to be perceived. This suggests that interactivity is only attributed to stimuli that are first perceived as animate, since animacy is already attributed to extrinsic motion and intrinsic motion congruency (Thurman & Lu, 2013). This mechanism seemed to have influence to the extent that even non-interacting dancers that at least maintained congruency between intrinsic and extrinsic motion (in study 3) were judged as more interactive than interacting dancers that had no congruency. Thus, the constraint of intrinsic and extrinsic motion congruency may be even more potent than actually having correlated joint and body movements for perceiving interactivity.
References

Which Level of Motion Processing, Global or Local, Plays the main Role in Generating the Repulsive After-Effect?

Izabel Khalili

Abstract

Despite the vast research on different types of after effect, little is known about the main generator of this delusion. Previous studies had demonstrated that two levels of local and global in the motion processing system are involved in motion after effect. This study identifies the main factors which drive the repulsive after effect (RAE) in the motion processing hierarchy by applying psychophysical methods. The experiment had three phases of adaptation, test and response. During the adaptation phase and the test phase subject was presented with a bunch of visual stimuli in form of Gabor patches. The participant determined the direction of test stimuli related to the vertical line in the response phase. The first critical step for this experiment was creating a design with conditions in which only local level or global level or both of these levels of motion processing system are involved in the after effect. The directions of adapting stimuli were the key element for controlling presence of the global level. When all adapting stimuli had the same direction of movement (45 degree for this experiment) the RAE induced at the global level, and when they had five different motion directions the global level wasn’t involved in generating the illusion. The locations of the test stimuli were the main factor for controlling presence of the local level in RAE. When the locations of the stimuli in adapting and test phase were similar, the local level was involved in the after effect, otherwise it was absent. Briefly, we had four conditions in which the RAE happened in only global level (Global-only), local level (Local-only), both levels (Adapt-Both), or no one of these levels (Adapt-Neither). We were interested in identifying the test stimuli that was perceived upward (PSE) in each of the four
conditions. The strength of the RAE for each condition was measured according to the size of shift of the PSE from the vertical line. As this shift is larger as the RAE is stronger. Our results indicate that presence of the global level in RAE leads to a significantly stronger effect while the influence of the local levels is weak and negligible. As a result, we can claim that the changes which happen in global level of motion hierarchy are the main generator of the RAE.

Keywords: global, local, adaptation, motion, after-effect, direction, location

After-effect is an illusion that results from repeated presentation of a stimulus during a period of time. Color after-image, tilt after-effect, and motion after-effect (MAE) are examples of this delusion. MAE has two versions of static after effect (SAE) and dynamic after effect. In the SAE version, after viewing a moving object (adapting stimulus) for a short time, a second stationary object (test stimulus) seems to be moving. In the dynamic after-effect the test stimulus originally is mobile, and there will be a shift in its perceived direction as a consequence of the after effect. If the shift for the perceived direction of test in DAE is away from the adapting direction the event is known as repulsive after effect (RAE), and if it is attracted toward the adapting direction that is known as attractive after effect (AAE). For a long time, researchers tried to discover the part of the visual system from which after effect comes. For example, Lehmkuhle & Fox (1975) were interested to find out if after effect occurs in eyes or in the brain. They observed that if adaptation stimulus be presented in one eye, the other eye could experience after effect. As a result, they concluded that after effect comes from the brain not neurons of the retina. Further studies demonstrated that two parts of the visual system in the brain can be involved in MAE. One is the V1 area which extracts local motion signals and the other one is MT area which integrates local signals and makes a global motion flow be perceived. After these group of discoveries, scientists were interested to learn about the changes that happen in V1 and
MT neurons during after effect. Dragoi et al. (2000) explored three changes in the local level of motion hierarchy by putting magnets in V1 area of cats while doing tilt after effect experiments on them. These three changes consist of neural suppression, shift in preferred orientation of neurons away from the adapting direction, and increase in the range of the orientations which the neuron responses to. Schwarts et al.(2007) investigated the effect of these three changes on the RAE separately. According to their findings, the neural suppression leads to RAE by itself. On the other hand, the other two changes (shift in preferred orientation of neurons and increase in the range of the orientations which the neuron responses to) cause AAE. The strength of each one of these three factors and their combination indicate the direction of the shift in the perceived stimuli in dynamic motion after effect. Kohn & Movshon (2004) discovered same type of changes in global level of motion hierarchy by putting magnets in monkeys MT area during MAE. These changes consists of neural suppression, shift in preferred orientation of neurons toward the adapting direction, and decrease in the range of the orientations which the neuron responses to. Opposite of local adaptation, in global adaptation all three changes lead to RAE. Now the question that comes up is that which one of these levels, global or local, drives the RAE? Curran and his colleagues (2006) tried to answer this question. They designed an experiment with adaptation stimuli with same direction of movement (45 degree). Their test stimuli had a fixed speed and a similar direction of movement which changed during the trials. The Participants determined the direction of perceived stimuli related to the vertical line. Their goal was finding PSE, that is the test stimulus that half of the times is perceived toward right of vertical and half of the times toward left of that, and investigating the strength of the RAE according to that. During the stages of the experiment the range of speeds of the local adapting stimuli were increased while the mean speed for the global motion was kept constant. In their
hypothesis, Curran and his colleagues had stated that if the RAE is driven by the adaptation of the motion sensitive neurons in the global level increasing the range of the speed present in the adaptor, while keeping the mean speed constant, should have no effect on the RAE magnitude. Since they obtained RAEs with different magnitudes, they claimed that this delusion is driven by the adaptation of local neurons. Our experiment had a design similar to Curran’s one, but instead of manipulating the speeds of the adapting signals as a key factor, we considered the motion direction of the adapting signals and the locations of the test signals as the elements which by their manipulation the presence and absence of the global and local levels in the DAE could be controlled. When all adapting stimuli had the same direction of movement (45 degree for this experiment) the RAE induced at the global level, and when they had five different motion directions the global level wasn’t involved in generating the illusion. In conditions that the locations of the stimuli in adapting and test phase were similar, the local level was involved in the after effect, otherwise it was absent. The test phase, response phase, and the method for measuring the magnitude of the after effect for our study were similar to Curran’s. After investigating the strength of the RAE for conditions in which only global level, local level, or both or neither of them are involved, opposite of Curran’s results, we recognized global level as the main generator of the DAE.

Method

Participants

Subjects of the experiment were students of University of California, Los Angeles. All of them participated in the experiment to get extra credit for courses they were taking.
Design

This experiment had 2X2 within subject design. There were two independent variables. The first IV was the direction of adaptation stimuli which had two levels of 1-direction and 5-directions. In 1-direction level, all local signals had the same direction of movement (45 degree), leading to perception of a global motion and intervention of the global detectors in the RAE. In the 5-direction level, the local signals had five different directions, so no global motion was perceived, and the global level was absent in the after effect. The second IV was the location of the test stimuli that had two levels of adapted and non-adapted. In adapted level, the locations of the test signals were chosen from those which already had experienced adaptation phase, causing the local detectors to have a role in the after effect. In the non-adapted level, the locations for the test signals were chosen from those which were absent in the adaptation phase, so the local level has no role in the after effect in this case. Test had four conditions in which the RAE happened in only global level (Global-only), local level (Local-only), both levels (Adapt-Both), or no one of these levels (Adapt-Neither). The experiment had sixteen blocks and twelve trials for each block. Half of the blocks were provided for 1-direction adaptation phase, and the other half were for 5-direction adaptation phase. In each block half of the trials were prepared for adapted test location and the other half of the trials were for non-adapted test locations. The sequence of the trials in each block was chosen randomly. The sequence of the blocks was in a repeating order. Each participant first took the block with 1-direction adaptation, then he took the block for 5-direction adaptation and then again he took the block for 1-direction adaptation and so on. Each trial of each block had three parts of adaptation, test, and response. The dependent variable was the distance between the PSE and the vertical which magnitude of the DAE was determined based
on that. PSE were the test stimulus that half of the times were perceived toward left of the vertical and half of the times toward right of that in each of the four conditions.

Material

The stimuli for the experiment were in form of gabor patches with one degree per diameter for their size, and 20 deg x 20 deg for their stimulus area. All of them had similar speeds. In the response phase the participant decided whether the direction of the test target was toward left or right of the vertical line by left and right button on the keyboard. The response was recorded by the computer. The PSE for each one of the four conditions was found by a mat lab program which we had adopted from the website http://www.palamedestoolbox.org. During the experiment trials, according to the subject’s performance this program chooses the fittest number for the direction of the test stimulus. The fittest number is the number that has a high chance to be chosen as the PSE.

Procedure

Before beginning the test, the producers of the experiment were explained for the participant. Before the main part of the experiment the subject was supposed to do a practice which the four conditions of the experiment were included in that. This helped the subject to completely learn the tasks before the real test. The main part of the experiment lasted 45 minutes, and had sixteen blocks with twelve trials for each block. Each trial had three stages of adaptation, test, and response. In each block, the first trial has a long (45 seconds) adaptation phase, while the following trials of the first trial in each block were shorter (6 seconds). In the test phase the participant looked at target stimuli for 0.72 seconds. In the response phase the participant had to determine, in less than 2 seconds, whether the perceived direction of the target test was toward left or right of vertical. During the adaptation phase and the test phase the participant was
supposed to adjust his gaze on the cross in the center of the monitor. This made him to put equal
attention to each stimulus and prevented bias. To avoid fatigue, there were one minute break
times between the blocks. During the experiment, the participant had to put his chin on a chin-
rest. That kept the distance between the monitor and the subjects’ eyes constant. The experiment
had a constant pace.

Result

The results of our test are briefly presented in Figure 1. We analyzed the data result of
our experiment with two ways within subject ANOVA. We did not have a significant interaction
F(1,11)=0.001, P=0.971. For the direction of adaptation the shift of PSE for 1-direction
adaptation stimuli (M=12.22, SD=1.778) was significantly stronger than the one for 5-direction
adaptation stimuli (M=3.26, SD=1.495), so we had a significant main effect for the adaptation
direction F(1,11)=21.085, P=0.001. Also, for the test location mean of earned PSEs for local-
adaptation test stimuli (M=8.93, SD=1.887) was not significantly different from the one for non-
local adaptation test stimuli (M=6.55, SD=1.383), so we did not have a significant main effect
for the test location F(1,11)=1.428, P=0.257. Also, by paired-sample t-test we compared the
means for the four conditions. the strongest DME happened in Adaptation-both condition. The
mean of the PSEs received from the subjects for Adaptation-Both condition (M=13.43) is
significantly larger than either the calculated mean from Local-only condition
(M=4.43), t(1,11)=4.92, P=0.00045 or Adapt-Nether condition (M=2.084), t(1,11)=3.82,
P=0.0028. The mean for Adaptation-Both condition (M=13.43) is not significantly larger than
calculated mean from Global-only condition (M=11.02), t(1,11)=1.23, P=0.24. the least amount
of DME strength was for adopt neither condition(M=2.084). This amount of DME strength was
significantly less than the one from Global-only condition (M=11.02), t(1,11)=3.806, P=0.0029,
but it was not significantly less than the one for Local-only condition ($M=4.43$), $t(1,11)=1.017$, $P=0.3306$. Furthermore the means for Global-only ($M=11.02$) is considerably larger than the one from Local-only ($M=4.43$) condition. $t(1,11)=2.535$, $P=0.027$. Finally, we were interested to check whether the motion after effect strength is considerably different from zero or not. 1-paired t-test shows that DME for Adapt-Neither condition is not significantly different from zero.

**Discussion**

The main motivation for designing this experiment was to find a psychophysical method for identifying the level of motion processing which plays the main role in generating RAE. The method applied to this experiment discovers this level by studying hierarchical adaptation at individual levels of processing. We investigated the magnitude of RAE for conditions in which global level, local level, both of them or neither of them were involved in DAE. Analyzing the data result shows that the magnitude of the DAE is significantly stronger when global level is involved compared to the conditions in which just local level or no level is present in the DAE. On the other hand, when the local level is present in the after effect, the change in magnitude of the RAE is negligible. According to these findings, we claim that the global level of motion hierarchy plays the main role in generating RAE. Previous experiments have discovered that during after effect three basic changes occur in the V1 neurons. One of these changes makes a shift in perceived stimuli away from the adaptation direction, and the other two make a shift in perceived stimuli toward the adaptation direction. These mentioned changes happen in MT neurons during DAE, but all of them cause the perceived stimuli to be shifted away from the adaptation direction. One can claim that since these three changes happen in a similar form in MT neurons, their combination creates a much stronger effect. As a result, the RAE is much stronger for conditions in which it happens in global level. In the future, researchers who want to
repeat our test can do it in a more controlled condition. For example, they can use eye tracker method to make sure that the participant’s gaze has been on the cross on the monitor during adapting and test phases. If the subject looks at another part of the monitor instead of the cross, the visual attention will not be divided between all local signals. In this case, there is not any effect for the global motion perception. It is possible that some of our participants have ignored the cross for some trials. In this case, deleting their data may cause us to find new results for local adaptation conditions. In sum, this experiment helps with better understanding of the underline mechanism of motion after effect as a psychophysical phenomenon.

Figure 1. Mean number of the magnitude of direction after effect in four conditions of Adapt-Both, Global, Local, and Adapt-Neither. Error bars represent standard error of the mean.
Reference


Effects of Neuropeptides on Social Working Memory

Jaekyung Won

Introduction

From a very young age, human beings are able to organize massive amounts of information emanating from different people, culture, social economics, governments and laws, and much more other instrumental factors. In just one simple conversation, there are two people, each with an immeasurable depth of history, all influenced by incredible amount of unique experiences. This all affects the nature of a how the person speaks, thinks, perceives and judges before one word is spoken. Yet somehow, despite the layers of social complexities, finding the right words to create essential meaning for the other person to comprehend seamlessly comes involuntarily. In other words, human beings are able to have their working memory process instantaneously and constantly deal with social situations on a moment-to-moment basis.

To address this phenomenon, this research is studying in depth the relatedness of this singularity with social working memory, which happens to be a rather controversial and upcoming research topic. Meghan Meyer from University of California, Los Angeles, has given more knowledge on social working memory and how it differs to working memory. Social working memory is working memory for social cognitive information and has a close correlational relationship with ‘mentalizing.’ Mentalizing is actively processing the psychological characteristics of others, of their mental states, and can include analyzing why their personality is so. Her research suggests that “demanding mentalizing can be conceived as requiring [social working memory],” which was supported by results from observing different regions of the brain lighting up when using functional MRI (Meyer, 2012).
The researcher I was involved with, Meghan Meyer, designed her tests to encapsulate data that may provide evidence for her hypothesis, with postulation of a positive correlation between high oxytocin and social working memory, and a negative correlation with working memory.

**Methods**

**Participants**

For each session, 6-12 participants age 18-21 (M\text{age}=20) were gathered to the study via proper ad placements in newspaper and fliers posted across the University of California of Los Angeles. All were gathered after extensive questioning to make sure the candidate’s health is qualified to deal with the side effects of snorting neuropeptides. The participants that did pass the extensive questioning were expected to not be pregnant, not have any signs of drug abuse, and have healthy vital signs. Participants was informed to be compensated $40 for approximately four hours of their time.

**Design**

The three independent variables were the influence of oxytocin, dopamine, and the controlled placebo. All this selection was double blinded against the experimenters to reduce biases, expectations and other confounding variables. There were four individually different tests on the participants influenced by oxytocin each with its own dependent variable. This allowed us to take advantage of the situation that may happen only few and far between, hence extra preparation to gather as much unique data as we can, as well as obtain the more focalized dependent variables for each test. These tests order were all randomized for the sake of counter-balance as well as to eliminate any order effects.
The researcher I was involved with designed her tests to potentially record strong evidence of positive correlation between higher oxytocin and social working memory and a negative correlation with working memory. There were two tests: alphabetizing task and the friend task. In the alphabetizing task, the participant will see a random list of three to four words that were chosen to induce little to no incitement. After three seconds the screen with list of words will be replaced by the next screen, which essentially asks the user to sort and alphabetize the words on the previous screen. For example, after a list of four words (dog, apple, bat, cat), the question may ask, “Using 1-4 where should ‘bat’ be ordered alphabetically in the list?” The reaction time will be recorded as the dependent variable. The friend’s task required preparing a genuine list of the participants’ friends in advance to be incorporated onto the list. The friend task was to calculate the reaction time of sorting out a list of three to four friends based on subjective questions rather than alphabetizing as before. For example, after a list of four personal friends (Meghan, Ben, Karina, Matt), the question may ask, “Who will most likely have the most children?”

Finally, the very last test asked participants to donate money after watching a video about either Darfur or children with Asperger’s. On the top left corner of the table, there was an envelope with ten extra dollars besides from the $40; the participants were informed they had the option to leave no money or $10 in the envelope before they leave.

Materials and Apparatus

The computer lab was reserved for all sessions with the participants arranged in seating as far from each other as possible. Firefox browser was used to do all the Internet questionnaire activities and MatLab was used to start the alphabet and friends task. Many research assistants were used to help assist and monitor the participants. The research assistants also collected urine
and utilized urine chemical testing strips to test for signs of pregnancy and incompatible signs of drugs. Newsweek magazines were given during the forty-minute limbo time period to prevent any unwanted stimulation. Extra ears phones were prepared in case any participants forgotten to follow directions.

Procedure

For each session, all were told to bring earphones (not headphones) and come at the same time to save time and ideally begin simultaneously. All the participants were assigned a number and sat down in their respective numbered computers. Each computer was prepared with four specially designed tests to obtain different dependent variables. Official nurses were called in advanced to help collect vital signs and give official medical approval to avoid legal issues and make sure the neuropeptide will not be of any damage to the participants. Additionally, the nurses were there to oversee participants correctly snort from a nasal spray containing either neuropeptides or a placebo.

However, due to legal regulations, the nurses could not fully administer the snorting ceremony. Instead, the research assistants had to administer the manual work and instructions. Inarguably, there could not have been enough emphasis on the fact that proper implementation of making sure the participants snort generous amounts of spray was the most important segment of the entire experiment. This was the biggest factor that caused uneasy feelings for experimenters when analyzing the data later on. After multiple test runs throughout the quarters, the experimenters evolved the instructions for the nasal spray more affirmatively to grow the confidence level for the results by making sure participants inhale the spray more than sufficiently well. For example, each participants were given practice viles to practice hand grip and positioning, as well as get familiar with the amount of force needed to press, as well as how
a proper spray will be sounding. After passing the practice run, the participants were carefully informed to prime the bottle to make sure the liquid is in the straw ready to be sprayed. The research assistant then instructed the participants will overall spray five sprays on each nose, alternating one by one, starting from the left, in 30 seconds interval. This whole process needed to be religiously monitored in order for the next three hours of the experiment to be externally valid. Despite the dynamically improving instructions, there still had been unfortunate instances of some participants who had a difficult time properly using the spray; some were overwhelmed of the spray to the nose and were crying, and some were sneezing uncontrollably.

After finishing the questionnaires, vitals, and passing the urine testing, the participant was approved to be given a magazine as the only source of interaction for forty-minutes—the recommended time it takes for the neuropeptide to be within effect. Every task were carefully monitored, timed, and recorded. After the forty-minutes were up, the participants were directed to start following instructions on the initial tasks on the computer. The research assistants were then attentive to help clarify any of the questions of the participants if they happen to be confused throughout the tasks. After all the tests were finished, each participant were debriefed, handed arbitrary food, drinks, and money to thank them with $40 for approximately four hour of their participation.

After every participant leaves, the research assistant gathers data carefully on all computers, record amount of money donated, and clean up

Discussion

Unfortunately, I was not personally able to gain any results from this quarter’s research experience. However, I was superficially able to count upfront how much money participants had donated after they left. Interestingly enough, participants either donated no money,
everything, or exactly half ($5). There is not much information to have a fully educated hypothesis, however it shows the intriguing nature of a simplified heuristic judging system for people dealing with money. Overall, I gained much valuable research experience and learned to fully appreciate social working memory on how truly fascinating the field is and see the value in investing on proper research and time.

The challenges we faced were mainly from the initial start of the quarter with new research assistants getting familiar with how everything will be running. Then the challenge was to optimally manage the time to run all the participants in an efficient manner. Although we were eventually prepared and equipped with experienced routine, one anomaly that no one quite thought of preparing for was how to deal with someone who fails the urine test for drugs, or the pregnancy test. Two females, and two males participants failed the urinary test for drugs, and handling this situation was not as thoroughly well prepared. This catalyzed our awareness in the gravity of the possibility of delivering the news that a female participant is positive for pregnancy.

The previous quarter, I, personally, made a mistake and caused five data to become useless. One of my responsibilities was to prepare the personal friend’s list and put them into the according computer. When I was extracting the files to place in the proper location within the computer, I had a hard time navigating through the files system and dragged and dropped incorrectly. This caused frustratingly amount of time and money wasted as well as priceless data lost.

This quarter, each preparation for the computers were more than double checked, yet still, there were a handful of anomalies throughout the multiple layers of preparation and transfer of files from the survey, to the online database, and to MatLab. Overall, I didn’t see any piercing
problems within our control with the structure of how the experiment was done. The design of
the experiment and tests was theoretically solid; however, the physical inconsistencies of the
participants in snorting the neuropeptides, random departures, and/or lack of attendance have
been a problem for the researchers. Additionally, from the main researchers, I learned that
research is heavily dependent on extensive competition for grants.

Social working memory is a young idea that has strong promises to develop into a better
understanding of differences between comedians, speakers, and leaders, who are “fast on their
feet” speakers, versus the opposite of why some people lack the ability to be socially adequate. It
will be interesting to study the development of the regions associated with social working
memory from an early age, as well as what factors affect the growth or stunt of the activation of
this brain area. Additionally, comparing the mind of an introvert yet brilliant author versus the
mind of an extravert has potential to be an interesting finding as well.
Reference


Researchers who study social working memory aim to explain how the human brain processes social information. Social cognition is crucial to a person’s everyday life, since it lies at the core of relationship-building and the ability to function well in a social environment. People interact with so many individuals each day and must keep track of the faces they encounter, as well as any new information they learn about each person, such as their concerns, goals, and moods. To accomplish this, the brain must work to store and manipulate the tremendous information it receives; therefore, social information processing requires much activity in the brain. Since social working memory is a relatively new concept of the psychological field, its specific mechanisms still remain a mystery. Some researchers, however, have uncovered some clues about the connection between social working memory demand and social cognitive ability, as well as which brain regions are involved.

Working memory, as explained in the article “Evidence for social working memory from a parametric functional MRI study,” involves “the holding and flexible updating of multiple pieces of information in mind.” Social working memory is the same concept but specifically involves information derived from social interactions. Regular working memory has been studied extensively, and results of most tests show that activity in the supplementary motor area and the lateral fontoparietal regions which are relevant to nonsocial working memory increases as a person receives and processes more material. These tests do not target social load, since they require participants to remember numbers or words rather than social information such as personality traits, so the results would not necessarily be the same for a social working memory test. One example of a working memory test is the n-back task, in which participants view a
screen as pictures of objects appear one at a time. If a picture is repeated, the participant presses a button. The n-back task can be varied in difficulty—for instance, the rules can be altered so that participants only press the button if a picture matches one that was presented two trials ago. This would increase the amount of information that the participants must maintain. With working memory studies, researchers have found that activity in the medial frontoparietal area, which other studies have found to concern social cognition, diminishes as the amount of information to memorize increases. Interestingly, the opposite occurs when social processing is involved, according to the study that is described in the “Evidence for social working memory…” article. When social load increased, medial frontoparietal activity increased in a linear fashion. The activity of the lateral frontoparietal region, though, increased just as it did for the regular working memory studies.

The study consisted of regular working memory tasks that were tweaked to incorporate social contexts. While being scanned in the functional MRI, the test subjects took a behavioral task performance test, ranking some of their friends by personality traits and then answering true or false questions about the order in which they had ranked their friends. The researchers examined the brain images to see which regions would have more activity as social load increased, and to investigate if the activity had a connection to perspective-taking, which relates to social cognitive ability. Since lateral frontoparietal activity resulting from regular working memory tasks is linked to fluid intelligence, which is “the capacity to make insights, solve new problems, and perceive new patterns to new situations independent of previous knowledge,” a similar relationship between social working memory and social cognitive ability seemed plausible (McNerney).
For the behavioral task performance, the researchers also observed the length of time that the participants took to respond to the true or false questions, because of the concept of mentalizing. Mentalizing, as described in the article “Social working memory: Neurocognitive networks and directions for future research”, is “the ability to think about mental states, traits, beliefs, and intentions” and relies on working memory, since people must store and manipulate what they learn from their interactions with others. Working memory is limited, since there is only so much that a person can store in his or her brain at one moment. Social working memory, then, should also have similar limitations—when social load levels go up, mentalizing performance will diminish. To analyze this notion, all test subjects were asked two weeks before they were scanned to rank ten friends based on personality traits, and this information was then compared to the subjects’ responses and reaction times during the actual scan. The researchers expected a decrease in accuracy and an increase in reaction time as the social working memory load grew. When the participants responded to questions about four of their friends, reaction time was much longer, as compared to when they responded to questions about three or two friends. Also, as expected, the participants’ responses were more accurate for trials that dealt with fewer friends.

Previous studies of social cognition tasks have revealed that the mentalizing network of the brain includes the medial frontoparietal, tempoparietal junction, posterior superior temporal sulcus (pSTS), and the medial prefrontal cortex (MPFC). Lesion studies have shown that when these regions are damaged, mentalizing is impaired. Other studies also suggest that when more cognitive effort is needed, the mentalizing network deactivates. According to this relationship, then, regular working memory and the mentalizing process could be compared to a seesaw. When the brain undergoes effortful processing, the lateral frontoparietal regions should activate
while the mentalizing network activity diminishes. However, in the study described in the article, this metaphor is no longer an accurate depiction, since the mentalizing network activity was observed to increase in response to higher social load.

Perspective-taking, or the ability to understand other people’s perspectives, was also a major component of the aforementioned study. To measure the participants’ perspective-taking ability, the researchers had them complete Empathy Interpersonal Reactivity Indexes (IRI) with the perspective-taking subscale. These are questionnaires in which participants evaluate how much they empathize with certain people, feelings, or situations. A sample question would state, “I sometimes try to understand my friends better by imagining how things look from their perspective.” A high score on the Empathy IRI correlates to better social functioning—people who empathize well are more competent in social cognition and have a bigger social network. From the study, the people with higher scores displayed load-dependent parametric increases in the MPFC. Interestingly, the MPFC is the only area of the frontal cortex that is significantly larger in humans than primates, with respect to body size. These observations fit well with the social brain hypothesis, which proposes that the prefrontal cortex of humans expands as evolution progresses in order to adapt to the need to maintain a growing number of social relationships. Social load, therefore, appears to play a major role in brain size.

Another method of evaluating perspective-taking is the Director task, in which participants view images of a director positioned somewhere by a shelf that displays an array of miscellaneous items. The participants hear instructions from this director to move certain items based on where the director is standing in relation to the shelf. For instance, if the director is positioned behind the shelf, then the participant should understand that the director cannot see any items that are blocked by the shelf walls. This task, therefore, requires the test subjects to
consider the director’s perspective. Studies involving this task have consistently shown that the MPFC and pSTS regions of the participants experience increased activity during the task. The superior dorsal MPFC has been observed to activate when people are thinking about the mental states of unfamiliar people, so it makes sense that the region would have more activity during application of the Director task.

Studying social working memory is important because the findings can be used to improve people’s social well-being. For example, psychiatric disorders such as schizophrenia, social anxiety, and autism spectrum disorders, involve impaired social processing and social working memory. With more knowledge about the brain regions involved in social cognition, researchers can formulate methods of treating these conditions. Training individuals in social working memory could potentially lead to improved social working memory ability, since this is the case with regular working memory. Working memory training correlates to better cognitive reasoning and fluid intelligence, so social working memory training could perhaps have the same effect on social cognition.

Much about social working memory still remains to be discovered. The results of studies offer great insight to the functioning of the brain under social situations. Social cognition is such an important aspect to a person’s personality and interactions with others, so a better understanding of the systems behind social working memory would open many doors to new ideas. The treatment of social psychiatric disorders, for instance, would experience significant changes—perhaps one day, psychiatrists can use techniques derived from social working memory research to assist schizophrenic patients. The possibilities are endless.
References


Curiosity has not changed much since last we visited it. It remains as enigmatic as ever, but our current studies has helped to shed some light on its effect on our memory. The current studies have not changed much since last we visited them and their basis on past relevant literature remains the same.

This study utilized the curiosity trivia questions paradigm of Kang et al. (2009) and Murayama & Khubander (2011). Kang et al. (2009) had participants read various trivia questions as they try to silently guess the answer and indicate their level of curiosity and confidence rating. After their guess they were shown the correct answer to the trivia question. Experimenters found that curiosity services a mechanic for “reward anticipation” and has an intrinsic value of learning. The results indicated that when the subject rated the trivia question with a high level of curiosity, they were more likely to remember the answer information later on. Murayama & Kuhbander (2011) utilized the same trivia questions paradigm but extended the experiment to include a form of monetary reward. They utilized a monetary reward condition and no monetary reward condition with the same procedure used as Kang et al (2009) to present the trivia question. A surprising find was that if someone rated a trivia question with high curiosity, the monetary reward was deemed not necessary in improving retention of the information. Again this relates to the “reward anticipation” mechanism where the effects of curiosity provokes emotion and experiencing this emotions seem to improve memory performance.

Germain & Hess (2007) studied different effects of motivation and differences in attention regarding relevant information and their effects on cognitive performance in older and
younger adults. Young adults and Older adults were shown various passages but with varying levels of relevance. Their results indicate the subjects were able to better remember information from passages that they found more interesting, however this effect was much bigger in older adults. Combining all these paradigms, the trivia questions paradigm and the results of Germain & Hess (2007), we arrive at the basis for our current study. We are attempting to replicate the findings of these previous studies and hopefully show that items that subjects find more curious are more likely to remembered and show a significant difference in performance on such items between young adults and older adults.

Experiment 1

Participants in this experiment were presented with 60 trivia questions in succession via PowerPoint presentation with one question presented at a time. An example of a trivia question used was, “What part of a woman’s body were ancient Chinese artists forbidden to paint?” The participants were told that it was unlikely they would know the correct answer and that this should not cause any distress as it was an expected part of the study. The participants saw each question for 12 seconds and during that period they were welcome to guess what the correct answer might be. After the 12 second period, with or without a guess, the participants were asked to provide a rating of how curious they were about knowing the answer as well as their confidence rating that they knew what the correct answer was. For their curiosity rating, a scale for 1 through 10 was used with 1 being not curious at all and 10 being extremely curious. It was emphasized the participants attempt to think about how truly interested and curious they were in knowing the answer. For the participants’ confidence rating, a scale for 1 through 10 was used, with 1 being extremely not confident they knew the answer and 10 being extremely confident they knew the answer. Participants were instructed to give all their ratings out loud for the
experimenter to record. After they provided their guess and ratings, participants were shown the question and the correct answer together for 6 seconds. After this phase of the experiment, the participants were given distracter tasks for approximately one hour. These tasks included a serial retrieval task where participants were asked to study and recall a series of lists of 15 words each followed by a free recall task. Also included was a retrieval task that asked the participants to answer a pre-test before studying the relevant information. After the material was studied, participants than took a post test containing similar questions. Another task used was a word pair task where the participants were asked to study word pairs presented in various conditions followed up by a recall task asking the participants to recall the correct missing associated word. After the distracter task period was over, the participants were then given a recall task with half of the trivia questions they were shown earlier. Participants were shown the trivia questions without the answer and asked to recall the correct answer. This was the short term delay recall. After a week, the participants were given a surprise follow-up call and were then given a recall task on the other half of the questions.

Experiment 2

Experiment 2 closely follows the procedure of experiment 1, with an added step. After the participants are shown the answer to the trivia question, they were asked to provide two more ratings. They were asked for their interest level now that the actual answer was known and the likelihood that they will still remember the information in the future. The interest level utilized a scale from 1 through 10 with 1 being not at all interesting and 10 being extremely interesting. Their judgement of learning rating used a scale from 1 through 10 with 1 being definitely WILL NOT remember and 10 being definitely WILL remember. Participants were asked to give their
ratings out loud for the experimenter to record. The experiment then proceeded with the same steps as experiment 1.

**Experiment 3**

Participants were given a sheet with a list of possible topics that may be used in the experiment. Some example topics included chocolate, Andy Warhol, and mummification. They were first asked to give an interest rating for each of the possible topics. Afterwards, they were instructed to place a check mark next to the two topics that they were most interested in and an X mark next to the two topics they were least interested in. These were the four topics to be used for the experiment. They were also asked to give a rating of how much knowledge they had of the topic. For each topic, the participants were shown 20 relevant facts, one at a time. They were shown each fact for ten seconds and following the fact, they were asked to give a curiosity rating and a judgement of learning rating. After the participants were shown the 20 facts, they were given a short distracter task of playing Sudoku for three minutes. Following the distracter task, the participants were asked to recall as many of the facts they saw as possible without a time limit. Afterwards, the participants were asked to give a post interest rating of how interested they were in the current topic after learning the 20 facts. They were also asked if they knew any of the facts beforehand. This process was repeated until all four topics were completed.

**Experiment 4**

Experiment 4 follows a similar structure to Experiment 3. Participants were given the same list as Experiment 3. They were asked to rate the topics the same fashion using the same interest scale. Afterwards they were asked place only one check mark next to the topic that they were most interested in learning about instead of two. Then they were asked to place an X next to the one topic that they were least interested in learning about. Finally, subjects were asked to
place a circle mark next to the topic they feel represented a moderate amount of interest in. This is the main change from Experiment 3. Instead of two high interest topics and two low interest topics, subjects were only shown one high interest, one low interest, and one moderate interest topic. Similar to Experiment 3, Subjects were asked to rate how well they knew each of the 3 topics that they chose using the same scale. They were then shown the 20 facts associated with each topic (order in which the topics were shown was counterbalanced) one at a time. Also similar to Experiment 3, after each fact a subject saw, they were asked to give an interest rating and a judgement of learning rating which were both the same scale as used in Experiment 3. After 20 facts were shown to the subject, the subject had to play a game of Sudoku for three minutes. After the distracter task, the subject was then asked to recall as many of the facts as they can remember without a time restraint.

**Results and Discussion**

The results indicate that the current study has indeed replicated the findings of previous literature for Experiment 1 and Experiment indicating that there is an effect of curiosity level on memory performance particularly for long term memory. The seemed to be a ceiling effect for short term delay as both younger and older adults remembered a majority of the trivia question answers when tested after a short one hour delay. Curiosity levels seemed to have no effect on recall performance. Perhaps this is due to the trivia questions being to salient as study materials in relation to the distracter experiments performed during the short term delay period. The interesting find lies in the long term delay results. There was a significant effect of curiosity on recall performance. The more curios the subject was the more likely they were able to recall the answer of the trivia question, but the effect was much more pronounced in older adults than younger adults. There seemed to be a significant interaction between age and curiosity level.
While overall older adults remembered less than the younger adults in the long run, their memory is much more selective than younger adults. They seem to tend to fixate on trivia questions that they find curious and thus more relevant causing an increase in motivation to retain that information, perhaps to utilize that information as a chance to relay it to their peers. Trivia questions with high curiosity seems to evoke some emotion mechanisms and bring with a sense of “reward anticipation”. When they find out an answer to a question that they were really interested in they find a sense of reward to discovering the answer and it feeds their curiosity on the subject. Also because Older adults lack the cognitive capacity of younger adults, they must be more selective in their memory storage causing them to be extremely selective in choosing which pieces of information they can retain in memory. For future studies, perhaps they study can be conducted under fMRI to examine if there are any changes in brain function when older adults and younger adults find a question curious or not.
References


Effects of Self-Explanation on Algebra Domain

Perry Reed

Causal contrast and self-explanation were used to explore problem solving in the What Is The Cause In Math experiment at the UCLA Reasoning Lab. Subjects were students at the University of California, Los Angeles who each took part in one condition of the experiment. Subjects received course credit for participation. The levels of the experiment were instruction type (causal contrast and traditional) and explanation type (self and experimenter). The experiment concluded that causal contrast instruction is the key factor in one's ability to solve novel algebra problems, not self-explanation.

In the current experiment, causal contrast refers to targeted comparisons of critical math concepts. It directs attention to the causal relation between a math operation and its goal. On the other hand, self-explanation proposes that learners infer missing information from example solutions; they use this to repair their mental model (Chi, et al, 1991).

The experiment was performed in two parts. During Part 1, subjects first took a pre-test to measure their current algebraic problem-solving ability. Then subjects completed one of four intervention tutorials, depending on their condition (causal contrast self-explanation, causal contrast experimenter-explanation, traditional self-explanation, or traditional experimenter-explanation). During Part 2, subjects returned after a 7- to 14-day delay and completed a post-test to measure their new algebraic problem-solving ability.

In the causal contrast instruction type, there were two kinds of questions that were asked. In the self-explanation, the subject may be asked, for instance, what made a novel equation containing both $x^2$ and $x$ more difficult to solve than the previous two equations. In the experimenter-explanation, the subject would be told, for instance, that the novel equation
containing both \( x^2 \) and \( x \) is more difficult to solve than the other two equations because they only contained either \( x^2 \) or \( x \) (Ye, et al, 2013).

One hypothesis of the experiment was that the self-explanation type, when prompted by causal contrast instruction, would teach subjects how to reason math concepts more than experimenter-explanation. This hypothesis failed to be supported by the results; there was no significant difference between the causal contrast self-explanation and causal contrast experimenter-explanation conditions. (Tangentially, there was no significant different between the traditional self-explanation ad traditional experimenter-explanation conditions either.)

This contradicts previous findings, which concluded that self-explanation of information improves understanding, and thus increases problem-solving ability on novel, but related, stimuli (Chi, et al, 1994). New procedural knowledge often must be integrated with existing procedural knowledge. Algebra is indeed a procedural skill - so why is self-explanation not significant in the current experiment?

In an experiment, Chi et al. had subjects self-explain their way through worked-out physics problems (1991). However, these subjects first read the prose sections of an introductory text-book; this provided context to the problems. On substep of a problem, for example, was "consider the knot...to be the body". This is already more context than a mere algebra problem can provide, with only numbers, operations, and variables. Similarly, an experiment by Ferguson-Hessler and de Jong (1990) had subjects self-explain their way through principles of electricity and magnetism; furthermore, these concepts were concretely tied to a manual of the Aston mass spectrometer, which again provided context.

Another experiment by Chi, et al, had subjects read a passage about the human circulatory system, either prompted to self-explain or not. However, biology involves a
systematic explanation that combines structure, function, and behavior (Chi, et al, 1994).
Although mathematics and algebra is part of a system, a multi-faceted systemic understanding is not necessary, nor overtly apparent, with procedural algebraic problems.

One previous experiment did use algebra (Nathan, Mertz & Ryan, 1994). The levels of the experiment were cognitive load (low or high), problem type (story-problem or traditional) and prompt (self-explain or none). The experiment found a significant advantage of self-explanation for algebra word-problems, but no significant advantage for traditional algebra problems. This supports the notion that contextualized problems, such as algebra word problems, are aided by contextual reasoning; however, non-contextualized problems, such as traditional algebra procedural equation solving, are not aided by contextual reasoning.

This notion was previously supported in a more general sense by research that had college students solve algebra problems in either word or equation format. The results, measured by response latencies, found that problem format influences the type of strategy that subjects use to solve algebra problems (Mayer, 1982). Hence, the story-problems used by Nathan, et al, are not comparable to the problem-solving strategies used for traditional algebra equations.

Mathematics is an interesting domain. Wearne and Hiebert described how symbols and rules must come from real-world context, but they “attain their power by becoming separated from these referents” (1988). Hence, mathematics creates an abstraction from real-world context, because once numbers and operands are converted to algebraic equations, they can be manipulated separately of their real-world meaning. The cognitive process is filled by the symbols and mathematical rules, not the real-world context. Hence, the self-explanation theory might not be applicable to mathematics, or at least algebra, because the cognitive process doesn’t connect the mathematics to any real-world application. Therefore, the experimenter-explanation
for the symbols and mathematical manipulations is sufficient; there is nothing further to be gained from self-explanation. The same processes are taught either way.

However, another hypothesis of the experiment was that causal contrast instruction teaches subjects how to reason math concepts more than traditional instruction. This hypothesis was supported by the results, which found that the causal contrast self-explanation and causal contrast experimenter-explanation conditions achieved significantly higher post-test results on transfer problems than the traditional self-explanation and traditional experimenter-explanation conditions.

Perhaps there is a two-step process in self-explanation when applied to domains such as physics or biology. There is the base-level operant procedure, and then a higher-level understanding of how that procedure fits into the mental concept. However, in algebra there is no “higher-level” understanding necessary to completely grasp the concepts.

In conclusion, The What Is The Cause In Math experiment does not support the theory that self-explanation is a domain-independent concept. Rather, superior achievement in solving novel math problems is due to causal contrasts rather than self-explanations. Perhaps we do not need to further explore why self-explanation does not apply to algebra: the causal contrast approach could be beneficial for education. Textbooks, online tutorials, etc. could be written using the causal contrast approach. Targeted comparisons of math concepts could direct attention to the causal relations between math operations and goals. There would be no worry about whether or not a student self-explains each step of the problem, because the results would generally be the same.

Overall, working in the UCLA Psychology Lab has been an enjoyable and rewarding experience. I have changed the way I think about reasoning and mathematics in the spectrum of
cognitive science, and I have learned valuable skills for conducting research. The concepts of causal contrast and self-explanation are very applicable to many domains outside of the so-far-tested physics, biology, computer programming, and now algebra.
References


Mirror-Drawing Task and Procedural Memory

Scott Korchinski

The mirror-drawing task is an experiment with historically significant roots in the field of psychology. The task involves a participant tracing shapes with a pencil on a piece of paper, but their vision of their hand and the paper is blocked by a shield. There is a mirror at the top edge of the paper, so all that the participant can see is a mirrored reflection of their hand and the paper (Figure 1). Thus, the participant sees a mirror image of the shape and their drawing, so that the perception of horizontal direction is the same, but perception of vertical direction is switched. A mirror-drawing experiment was used by Milner (1962) on an amnesiac patient, and the results from this experiment sparked a drastically new view on memory that has been developing ever since. Present day mirror-drawing techniques use computer programs to simulate the task, with the mouse movements reversed in a vertical direction to mimic the real-life, analog version. The mirror-drawing task involves visual and motor skills, which combine to test the participant’s hand-eye coordination. Past research has shown that participants learn this skill when a complex shape, such as a star, is being traced, but in general cannot accurately recall aspects of the learning rule afterwards. Thus, using simpler shapes like circles, squares, and triangles will hopefully allow the participant more experience with the learning rule in a simplified format, thereby causing the participant to be more accurate in identifying the learning rule.

The process of acquiring the skill needed to carry out the mirror drawing task illustrates the development of one of the two types of long-term memory: procedural memory. Procedural memory is formulated through repetition of a specialized action towards a specific goal. In contrast, declarative memory is formed through fact memorization and personal experiences. The
mirror drawing task improves procedural memory so that the skill of tracing the shape becomes increasingly efficient and accurate.

The significance of this type of experiment was illustrated initially by Scoville and Milner (1957) and their work with Henry Molaison, known fondly by students, professors, and researchers in the field of psychology as patient “H.M.” As an adolescent, H.M. suffered epileptic seizures due to brain damage resulting from a childhood bicycle accident. He was referred to Scoville, a neurosurgeon, for treatment, and his left and right medial temporal lobes were surgically removed. The surgery was successful in repairing the symptoms of H.M.’s epilepsy, but the removal and destruction of the majority of his left and right hippocampi and amygdalae left H.M. with a severe case of anterograde amnesia. His working and procedural memory were unaffected, but he was unable to store novel experiences and information with his explicit memory. Milner’s extensive experiments (1962) with H.M. included the mirror-drawing task, in which H.M. used a pencil to trace a star while only being able to see his hand and the drawing in a mirror. H.M. was able to acquire this skill after ten trials, and retained the skill for three consecutive days, yet “at the end of testing, he had no recollection of having done the task before” (Squire, 2009). Milner’s discovery about H.M.’s separate categories of memory formations was the first piece of evidence towards the view of memory that we now have today: that there are distinct types of memories that can be stored in the brain, and different physical components of the brain are used to store them.

The mirror-drawing task measures a participant’s ability to improve procedural memory on a tracing task through repetition of the task, which leads to procedural learning. A past experiment, performed by Dr. MacKay and Johnson, used a five-pointed star shape for the training phase (Figure 2). This experiment showed that participants decreased their overall
tracing time and made fewer errors on the task as a result of practice. On a quiz after the training phase that asked participants to how to move a dot from one point on a star shape to another using the mouse movement rule from the training (Figure 2), participants correctly answered significantly more questions than the control group that did not undergo training. However, the training group correctly answered only slightly more questions than would be expected by chance, averaging 2 out of 5 correct answers. On a similar quiz with a new shape – a two-sided arrow – used as the basis for the questions, the participants answered slightly worse on average than they did on the star shape quiz. Finally, in response to a quiz that asked the participants to describe the mouse movement rule, only one third of the trained participants got this correct.

These results were statistically significant in the direction that the researchers expected, but were not as remarkable as the researchers had hoped. The results can by summarized by Barnes (1992), who states that there are numerous situations “in which individuals (a) show a conceptual understanding of some topic but lack procedural skill or (b) show procedural skill but lack a conceptual understanding” (p. 237). By simplifying the shape, it could be possible to discern whether there is a conscious component to the mirror drawing task, or if it is truly a purely implicit motor task, as the previous literature suggests. Related research by MacKay and James (2009) states that H.M.’s visual cognition deficits “cannot be explained in terms of explicit learning and memory, working-memory limitations, temporary retrieval failures, forgetting (or failure to maintain in memory) the targets in the Hidden-Figure task, or deficits involving explicit learning and recall of episodic and semantic information” (p. 785). This suggests that there is more to H.M.’s ability to perform the mirror-drawing task than simple procedural memory based skill-learning, which has led to further questions of how he was able to successfully complete the task.
The relatively unimpressive results of the past experiment could be due to the complexity of the shape that is used during the training phase. Because of this, a new experiment is being formed that aims to use a simpler shape during the training phase to test if the rule for moving the mouse could be better learned. Using a simpler shape could assist in learning because the participant would have fewer directional changes to make, and thus spend more overall time moving the mouse in the same direction. For example when tracing a star, the participant must constantly shift directions to move around the 10 angles and sides in a five-pointed star. However with a square, a participant will only have to move around four angles and sides. Thus, they will spend a relatively longer time moving in the same direction, which will eliminate the need to constantly keep track of several directions of motion, thereby giving the participant more time to become familiar with the necessary mouse movement rule. The same goes for a triangle, with three points and angles. A circle shape would be an interesting combination of a simple shape and complex shape because it does not have any angles but the participant must still keep track of several directions of motion at once. Thus, with simpler shapes, one could expect that response time will decrease quite rapidly with practice, and the number of errors will decrease rapidly as well. The control group’s performance on the quiz should be equivalent to performance on the past study, about the same as chance, while the trained group should perform much better.

The past study used a purchased program that did not contain simpler shapes. Thus, I have begun working on a new program that will do the same thing as the previous simulation, but will use a square, circle, and triangle. So far, I have used HTML to create a website that contains the program. An HTML canvas element is used to contain the shape. The instructions, mouse coordinates, timer, and game status – “not started,” “in progress,” or “finished” – are
displayed using HTML elements. These elements are updated throughout the experiment using JavaScript functions, and the majority of the program will be based on JavaScript functions. So far, I have made functions to draw the shapes to the canvas, composed of a larger outer shape and a proportionally smaller inner shape to create the track that the participant will draw inside. There is also a function to keep track of the mouse coordinates, which are displayed when the user clicks inside the shape, and disappear when they click inside the shape again. Another function keeps track of the time elapsed from the first mouse click to the second mouse click.

I now have to create a beginning area for the task in which the user must click to begin, and keep track of elapsed time until the user releases the mouse, instead of when it is clicked again. Also, I need to set the inner and outer shapes as the boundaries for the track, and display an alert when the user crosses these boundaries, as well as update a counter for the number of times a boundary is crossed. Another important function that still needs to be implemented is the inversion of horizontal movement of the cursor on the screen. Finally, I need to send the results of each trial to a database (via email, Microsoft Excel, or MySQL), so that multiple trials can be run seamlessly without requiring the experimenter to write down the data after each trial.

Future studies could split up the participants into three groups: one that trains with the five-pointed star shape, one that trains with a simpler shape like a square, and one control group. These groups could then be compared to determine the rate at which learning occurs between the two training groups, and performance on the post-training quizzes about the learning rule for mouse movement. The results from these experiments could be analyzed to determine whether procedural learning is the sole factor behind skill learning for the mirror-drawing task, or if a more conscious, declarative type of memory is being used in conjunction.
Figures

Figure 1: The classic setup for the mirror-drawing task in which the participant must use a mirror to trace a shape.

Figure 2: The five-pointed star shape used for training in the mirror-drawing task and the post-training quiz.
References


Art and Causal Parsimony

Tanya Zamorano

Abstract

How did we come to evolve to let art play such a prominent role in human life? We seek to determine what caused humans to evolve to cherish art even though it is not obvious why art is necessary for survival. It must be compared to something that is more evolutionary adaptive like causal explanations. People often prefer the most parsimonious of causal explanations, so parsimony may also play a role in the evolution of art. We test this by having participants judge causal paradigms, statements of logic, and paintings. Not surprisingly, results indicate that participants chose the most parsimonious answer. This experiment is just the pilot of a larger study whose ultimate goal is to use fMRI images to determine whether aesthetic and causal judgments activate the same parsimony area of the brain.
Introduction

Since prehistoric times, art has been highly appreciated and today art is valued across all cultures. Since art did not evolve as an adaptation, it may have evolved as an exaptation, which means it utilizes a feature that was developed through natural selection. This feature, called parsimony, is a cognitive process found in causal explanations. Humans have a natural tendency to find cause and effect relationships because it is necessary to be able to predict and control situations. There are usually many possible explanations for what caused something to happen, so humans developed a method for which explanation to choose. We tend to prefer the parsimonious explanation; the simplest explanation that can describe all the observed facts and is not more complicated than necessary.

Visual perception also uses parsimony. Countless stimuli hit the retina every second; yet humans tend to perceive only the most parsimonious interpretation. Since visual perception already uses parsimony, it is possible its use got extended to aesthetic judgment. Therefore our appreciation for our may just be a by-product of the evolution and adaptation of parsimony.

Method

Participants

Ten undergraduate students (7 female, 3 male) at the University of California, Los Angeles volunteered to participate in this study.

Materials

The experiment was programmed using PsychoPy and participants completed the study on the computer. The paintings used in the art task were computer-generated fractals.

Design

This experiment used a within-subjects study where participants were in all three
conditions: causal paradigms, logic, and art. Parsimony was measured by participant’s judgments in each of these conditions. Only there choice between two possible choices (explanation, diagram, or painting) was recorded as a measure.

Procedure

Participants were given as much time as they needed to complete three tasks on the computer. Each task was composed of three trials. In the logic task, participants saw ven diagrams depicting the relationship between two groups of fictional objects (e.g. blorks and vings). Their task was to figure out a good description of the depicted relationship. For each trial, they were shown two sentences that may or may not have described the relationship depicted in the diagram and then had to judge which sentence was easier to understand. In the causal paradigm task, participants observed episodes in which people ate exotic fruit and sometimes developed a rash on their face, which was symbolized by red dots. Their task was to figure out an explanation for when the rash appeared. For each trial, they saw two episodes of a person and then saw two diagrams that may or may not have explained the episodes. Each episode included the fruits that the person ate and a picture of their face with or without a rash. Each diagram contained green, red, blue, or gray arrows pointing from the fruit to the person. Green arrows meant that the fruit caused the rash. Red arrows meant that the fruit protected against the rash. Blue arrows meant that two fruits in combination either caused or prevented the rash. Grey arrows meant that there was no causal relation between the fruit and a rash. At the end of the trial, they had to judge which diagram was a better explanation of the episodes. In the art task, participants saw a pair of paintings. In each trial, they had to indicate their preference between the two.
Results

In the logic task, a majority of the participants chose the most parsimonious sentence \( (M = .98) \) as the one easiest to understand as shown in Figure 1. For example, most thought that the sentence “no blooks are vings” was easier to understand than “all blooks are non-vings.” In the causal paradigm task, a majority of the participants also chose the most parsimonious diagram \( (M = .63) \) to be the best explanation of the episode as shown in Figure 2. In the art task, a majority of participants chose the most parsimonious painting \( (M = .70) \) to be the most visually appealing, as shown in Figure 3.

Discussion

These results are not very surprising, but since a majority of the participants made judgments that we expected, we can move on to the next part of the study. The future goal of this study is to run participants through it while looking at fMRI images of their brain. Since parsimony plays a role in causal explanations, the parsimony part of the brain should be activated during the causal diagrams task. If parsimony plays a role in the evolution of art, then the same parsimony part of the brain should be activated when participants make aesthetic judgments in the art task.

This pilot study only contained easy tasks, so in the future we will include trials that are increasingly difficult for participants to judge. An alternate explanation for why the causal diagrams and aesthetic judgment task activate the same brain region may be that the greater effort that is required for increasingly difficult tasks is what makes the same region in the brain activate. However, this is why the logic task was used as the control. When the difficulty of logical statements is increased, a different area of the brain than parsimony should be activated. If this turns out to be true, then we can say that the difficulty of a task and parsimony are not
related. Then parsimony would be the link between art and causal explanations. Upon completion of the study, we hope to conclude that parsimony was selected for causal explanations and its use in art is the result of an exaptation.

Figure 1. Participant’s judgments on which sentence was easier to understand.

Figure 2. Participant’s judgments on which diagram was a better explanation of the episodes.
Figure 3. Participant’s judgments on which painting they found more aesthetically pleasing.
Top-down Influences of Action Prediction and Action Interaction on Stimulus Visibility during Binocular Rivalry

Ye Eun Chun

Introduction

What we see right now is not just a cluster of visual inputs to our eyes, but we select the more informative visual inputs, process them and finally perceive them. Then what kinds of information can influence our visibility on a certain visual stimuli?

According to article “Predicting point-light actions in real-time”, visual perception was not simply reconstructed from visual input, but it was a predictive activity (Markus et al., 2007). This idea has been supported by the results from many previous studies of neuro-imaging. Brain areas, such as MT which processes real motion, were activated when static images with implied motion were presented (Kourtzi and Kanwisher, 2000). Other researchers also found that superior temporal sulcus (STS) coded biological motion when it was implied from static postures (Jellema and Perrett, 2003b). However there was not much evidence found about the timing of these predictive aspects, so a study of the prediction of human actions involving real-time simulation processes, was conducted (Markus et al., 2007).

In order to show animated human actions to subjects, they used the technique known as point-light animation of biological motion. With point-light animations, the human action is portrayed by small point lights placed on the head and the joints of the body (Randolph, 2007). The great advantage of using point-light actions is that observers can judge sex and the emotional implication of a point-light defined walker when viewing the animation of the whole body. With this technique, experimenters motion-captured a number of human actions and made them as point-light action animations. During the experiment, subjects watched sequences of
point-light actions, followed by an occluder and then a static test posture. After that subjects were asked to judge whether the test posture depicted a correct continuation of the action before the occluder. Occluder time and the movement gap, which is the time between the endpoint of the action and the static test posture, were varied; occluder time (100ms vs. 400ms vs. 700ms) and movement gap (100 ms vs. 400ms vs. 700ms). Error rates were lowest when occluder time and movement gap corresponded. These findings suggest that action prediction involves a real-time simulation process.

According to article “Communicative interactions improve visual detection of biological motion”, they found that participants detected the target actor better when the target was embedded in a fighting sequence (Manera et al, 2011). This result suggested that interaction inferences can influence sensitivity for detecting the target in visual noise.

Based on the previous studies, we tested how action prediction and action interaction influence on stimulus visibility.

**Experiment 1: Top-down influence of action prediction on stimulus visibility during binocular rivalry**

**Method**

**Participants**

Fifteen UCLA undergraduate students participated in this experiment. Subjects were given a course credit for their participation.

**Design**

A 2x2 within-subjects design was used for this experiment. The first independent variable (IV1) was represented by two levels of occluder time; 200ms or 800ms. The second independent variable (IV2) was represented by two levels of matchness between stimuli in probe movie and
test stimuli after occluder; Match vs. Mismatch. The dependent variable (DV) was the percentage of correct responses out of all responses.

Materials and Apparatus

We used stick figures in probe movies and point-light human figures in test movies. A point-light human figure consists of 13 dots; 1 head and 12 joints of the body.

The experiment consisted of five parts: a learning session, a practice for block 1, actual experiment of block 1, a practice for block 2, and actual experiment of block 2.

Learning session consisted of two sub-parts; presentation phase and recognition test. In presentation phase, 6 different movie sequences were presented (A pulls B and B resist; A pulls B, B resists, but B loses; Scramble for last seat, A loses and stands up; High-five; A sits, B pulls up A; A picks up stool, threatens to strike B) and they were repeated once. In recognition test, 24 trials were given to a subject. In each trial, an actor depicted an action sequence from either the previous presentation phase or new sets of movie sequences, so that subjects judged whether each trial movie was old (shown in the previous presentation) or new (wasn’t shown in the previous presentation).

In each actual experiment block, 10 practice trials were given in the beginning. There were two blocks totally. Each block consisted of 48 trials. 200ms occluder time trials and 800ms occluder time trials were placed in an intermixed order. Also two different matchness conditions (Match vs. Mismatch) were equally distributed within each block. For each trial, it consisted of two tasks. One was to judge which human figure was more visible during two test stimuli were conflicting. The secondary task was to choose the facing direction of the green figure in a probe movie.
The target figure in the 200ms occluder time condition had a movement gap of 200ms, while the incorrect figure in the 200ms occluder time condition had movement gap of 800ms. Vice versa for the 800ms occluder time condition, the target figure in this case had a movement gap of 800ms while the incorrect figure had movement gap of 200ms. The number of target figures was counterbalanced for both eyes (left or right) and two colors (red or blue).

The size of the frame was 350 pixels when screen resolution was 1208×1024 pixels and the refresh rate was 75Hz. The luminance level for figures in probe movie was 8cd/m² and there was luminance difference between target stimuli and distracter stimuli. Target stimuli are always 7cd/m² brighter than distracter stimuli; 10cd/m² for target stimuli and 3cd/m² for distracter stimuli.

Probe Movie

Test Stimuli
Procedure

During the experimental session, a participant sat in front of the computer. First the participant was informed the instruction of the experiment and then placed the face on the chin rest. The chin rest makes the distance from a subject’s face to screen fixed with 47cm. When the participant looked through the binocular mirror to see the monitor, the instructor turned off the light of the testing room so that the participant could fuse the two images on the participant’s each eye easily. When the participant confirmed with clear vision through binocular mirror, then learning session began. In this session, 6 different motion sequences were played and repeated again. Right after this presentation, the participant was required to complete the recognition test which consisted of 24 trials by using arrow keys (left key for new movie, and right key for old movie). This recognition test repeats until the participant reached above 75% correct out of 24 trials to continue on prediction rivalry task. In the beginning of each actual prediction task block, 10 practice trials were given. Each 48 actual trials for each block so total 96 trials for two blocks were required to be completed. After all rivalry task completed, the participant was required to answer to 50 questions about the subjects’ autistic traits, and then the experiment ended.

Results

Figure 1 indicates the average accuracy rate. Looking at the pattern of results showed in Figure 1, it presents that average accuracy rate, in general, is higher when occluder time is
800ms than when it is 200ms and also when the test stimuli are matched to the probe movies than when they are mis-matched.

To test these effects, the data were analyzed by using a 2 x 2 (Occluder time [200ms, 800ms] x Matchness [Match, Mismatch]) within subject analysis of variance (ANOVA). This result presented significant main effects of both Occluder time and Matchness. In particular, when Occluder time was 200ms, the difference between matched and mismatched conditions was greater ($t(1,13)=2.064, p=0.058$) than when Occluder time was 800ms ($t(1,13)=0.452, p=0.658$). However, the interaction between occluder time and matchness was not found to be significant.

Figure 1. Effects of occluder time (200ms vs. 800ms) and matchness (Match vs. Mismatch) on accuracy of predicting human action.

Experiment 2: Top-down influence of action interaction on stimulus visibility during binocular rivalry
Method

Participants

Ten UCLA undergraduate students participated in this experiment. Subjects were given a course credit for their participation.

Design

A 2x2 within-subjects design was used for this experiment. The first independent variable (IV1) was represented by two levels of Interaction; With Interaction and Without Interaction. The second independent variable (IV2) was represented by two levels of Matchness between a male dancer and a female dancer; Match vs. Mismatch. The dependent variable (DV) was the percentage of actor selected out of whole period of each trial.

Materials and Apparatus

The experiment consisted of three parts: practice session, block 1 and block 2.

In practice session, 4 trials of two Upright walkers were presented. Each walker was presented to each eye, and it can be either red or blue and they are either facing to each other or facing away from each other.

Block 1 consisted of 32 trials of Without Interaction conditions. In Without Interaction conditions, only a female dancer was presented in the right side of the frame. Each female point light actor was composed of 6 random dots from the 8 body segments and 1 dot on the head. This female dancer was either from 4 salsa dancing motion sequences as Matched condition, or from non-salsa dancing sequences (either laughing person or Indian dancer) as Mismatched conditions.

Block 2 consisted of 32 trials of With Interaction conditions. In With Interaction conditions, a green male dancer was presented in the left side of the frame, and a female dancer
in the right side of the frame. Each green male figure was shown as a stick-figure and each female figure as 6 random dots and 1 dot on the head. Female dancer stimuli for Matched condition and Mismatched conditions were same as block 1.

**With Interaction: Matched (left) and Mis-matched (right)**

![With Interaction: Matched (left) and Mis-matched (right)](image)

**Without Interaction: Matched (left) and Mis-matched (right)**

![Without Interaction: Matched (left) and Mis-matched (right)](image)

**Procedure**

In the experiment, subjects were asked to indicate which color is more visible by holding down the arrow keys; left arrow key for blue, right arrow key for red and down arrow key for equal visibility. Then their time spending on holding keys for each stimulus was measured. Four trials of practice session was given to subjects first, so that they could learn how to response to the test stimuli. And block 1 with 32 trials and block 2 with 32 trials were followed.
Results

Figure 2 indicates the percentage of an actor selected during trials. Looking at the pattern of results showed in Figure 2, it presents that average percentage of an actor selected, in general, is higher when male and female dancers were matched than when they were mis-matched.

To test these effects, the data were analyzed by using a 2 x 2 (Interaction [With Interaction, Without Interaction] x Matchness [Match, Mismatch]) within subject analysis of variance (ANOVA). This result presented a significant main effect of Matchness. The difference of percentage of an actor selected between Match and Mismatch was significant when there was interaction (t(9)=3.18, p=0.011), but no significant difference was found when there was no interaction. Also their interaction effect between Matchness and Interaction was found to be significant (F(1,9)=5.911, p=0.038).

Figure 2. Effects of interaction (With Interaction vs. Without Interaction) and matchness (Match vs. Mismatch) on percentage of an actor selected.
Conclusion and Discussion

From the results of experiment 1, we found the significant difference of correct response rate between Match and Mismatch conditions in occluder 200ms. For both occluder times, Mismatch conditions worked as a base line for subject’s bias toward a certain stimuli. Therefore the difference between Match and Mismatch conditions can be interpreted as a predictive activity. Therefore from the results, we can conclude that this prediction activity enhanced the stimulus visibility.

From the results of experiment 2, we found the significant main effect of Matchness especially in Interaction conditions. That means subjects tend to see more of an actor which interacts with a matched partner. Therefore from the results, we can conclude that action interaction can enhance the actor’s visibility.

Therefore from the two experiments, we can conclude that high level action information can influence the perceptual ability at monocular channels.
References


