Canadian Undergraduate Journal of Cognitive Science

A refereed journal for and by Canadian undergraduates interested in cognitive science-related topics.

http://www.sfu.ca/cognitive-science/journal/

Fall 2003 Issue

IN THIS ISSUE:

Published by the Simon Fraser University Cognitive Science Student Association.

Undergraduate Journal of Cognitive Science

The Canadian Undergraduate Journal of Cognitive Science is an electronic journal published by the Cognitive Science Student Association at Simon Fraser University. Our aim is to provide a forum for students to share work amongst peers and gain valuable experience in the process of getting an academic paper published. As a publication, CUJCS provides a unique reference for students, showcases research by other undergraduate students, improves the contact and exchange of ideas between Canadian students and cognitive scientists alike, and illustrates the interdisciplinary work that is the hallmark of cognitive science everywhere.
Although preference is given to Canadian students, contributions from students elsewhere are strongly encouraged.

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ISSN: 1499-7487 (Online Version)
1499-7495 (CD-ROM Version)

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The Editors also appreciate any offers by graduate students or faculty in cogsci-related disciplines for refereeing.

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INTRODUCTION

Welcome to the second edition of the Canadian Undergraduate Journal of Cognitive Science (CUJCS) -- a forum for the interchange and promotion of ideas between undergraduate cognitive science students. In publishing the work of these students, we not only hope to offer a means to disseminate undergraduate research ideas, but also to provide an opportunity to experience the process of academic publication.

Still in its infancy, CUJCS has faced some new and interesting challenges over the last year and a half. Unfortunately, some of these ultimately resulted in the unavoidable delay of this year's publication. As such, we wish to thank all of our contributors, as well as our readers, for their patience and continued support during this time. We are dedicated to the ongoing improvement of our journal, and will continue to learn from both our mistakes and our successes to ensure that CUJCS becomes the principal undergraduate cognitive science journal in Canada.

We would like to take this opportunity to thank each of our authors whose submissions continue to make our journal possible. This year saw a number of interesting and varied research papers comprising a wide range of areas of investigation within cognitive science. Each paper was subject to at least two reviews before the final decision on acceptance was made. Those that were selected particularly represent not only the cognitive science methodology, but also the qualities of high-level discourse found in journal-quality papers, namely strong presentation, cohesion, clarity of thought, and evidence of critical thinking. As learning to write such papers is an ongoing process, those that were not selected for this year's edition were nonetheless encouraged to revise based on the referee's comments and to consider resubmitting for the 2004 edition.

In addition to our authors, a great deal of gratitude is owed to the faculty and students at our fellow universities and colleges who assisted in distributing our Call for Papers, and in encouraging their undergraduate students to participate. We would also like to thank our faculty advisors, Dr. Nancy Hedberg and Dr. Rodger Blackman, whose continued encouragement and assistance has helped bring this project to life; the members of the Simon Fraser University Cognitive Science Student Association (COGS) for their contributions in all aspects of the journal; our referee committee, comprised of graduate students and faculty from Simon Fraser University, Carleton University, Rutgers University and Washington University; and last, but not least, our Referee Coordinator, Doug Yovanovich, as without his efforts this year's edition would have surely turned into next year's.

Finally, we look forward to continuing to provide such opportunities for our undergraduate cognitive science students in the years to come.

In closing, we hope that you will find the 2003 edition of CUJCS both stimulating and engaging. So please, grab a coffee, a comfortable chair and enjoy!

Canadian Undergraduate Journal of Cognitive Science
Editorial Committee

The Current State of Insight Research

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Abstract

Examines existing definitions of insight and insight problems, revealing a lack of consensus and clarity, subsequently proposing what would be necessary in a legitimate definition of an insight problem and possible means of reaching one. The lack of consensus implies that experimental uses of insight problems lack validity, since the current *de facto* determiner of what constitutes an insight problem is not the problem itself but the effect it produces. So-called 'insight' problems are seen to be an inconsistent set where multiple undefined influences may be at play in causing the requisite 'Aha!' experience. It becomes apparent that a detailed analysis of 1) what is insight, 2) what constitutes an insight problem, and 3) how we can create new insight problems, is necessary for the field to move forward.

The Current State of Insight Research

The phenomenon of insight was first proposed by Gestalt psychologists around the first quarter of the 20th century. In the Gestalt theory of mind, insight was described as the sudden finding of a solution to a particular problem, which can be attributed to successful problem restructuring. However, without a functional definition of this restructuring, it provides neither a useful definition of the phenomenon, nor does it facilitate an explanation for how it occurs. Breaking insight down into its definition and explanation is important and can be justified on the grounds that it helps to avoid circularity (Schooler, 1995). Without the distinction, insight remains in a constant state of flux, as its meaning is closely dependent on its mechanism. In fact, some psychologists still consider the term 'insight' to be entirely meaningless (Dominowski & Dallob, 1995). Attempts to describe and explain this phenomenon since the Gestalt period have nevertheless continued. This research, however, has been plagued by the original faulty assumptions of Gestalt psychologists, and their use of dated and arbitrarily chosen 'insight problems'. The crucial obstacle confronting insight researchers could thus be seen as the inadequacy of the definition of insight and insight problems. This has caused the field of insight research to grind to a halt. To proceed any further, a new perspective is needed on what true insight problems are as well as a theoretical foundation for their creation. Without these, there is little hope of reviving this ailing field of cognitive science.

An adequate definition of insight should allow for the invention of insight problems in an exact and predictable manner. It should be a set of necessary and sufficient conditions for a problem to belong to the class of insight problems. A rigorous classification of insight problems has been stressed, because at present problems are normally chosen from previous studies without regard for what makes the problem truly an insight problem (Wieth & Burns, 2000).

Worse yet, it seems as though little thought has been given as to how any two insight problems involve similar processes.

One useful view of insight gleaned from the current literature is a simple one, but a look at its development is needed to appreciate its functionality. Richard Mayer's definition, that it is the '[sudden move]' from a state of not knowing how to solve a problem to a state of knowing how to solve it" (1995), is a good place to start; however, the consideration of other current definitions leaves the reader, in most cases, perplexed by their vagueness. Mayer's abstraction of the Gestalt view of insight describes insight as 1) completing a schema, 2) the reorganisation of visual information, 3) the reformulation of a problem, 4) the overcoming of a mental block, and/or 5) the finding of a problem analogue. Thus the question becomes what problems, if any, are *not* insight problems? In truth, these definitions of insight are relatively useless; there is no way that the above views are definitions in the more rigorous sense.

The first view, completing a schema, is described as the filling in of a gap in a coherent set of data. This does little to help explain insight, and fails to help classify insight problems, as this definition requires an understanding of what a schema is, and what it is to complete it (Mayer, 1995).

The second view, that insight is the reorganisation of visual information, does slightly better: in the specific case of visual problems, it is the redistribution of the problem's components. However, this involves the implicit assumption that the problem's components can be organised in the first place (a problem of relevance), and that they can be subsequently reorganised (a changing in the structure of the relevant parts). That is, as in many definitions, the terms used are in themselves imprecise (Mayer, 1995).

The third view, that of reformulation of a problem, was proposed by Gestalt psychologist

Karl Duncker. Essentially, it is the redefinition of the goal, or the redefinition of the given information. We can now begin applying this definition to proposed problems. That is, a problem is an insight problem if a solver's initial approach to it cannot solve it. Hence, a change in approach provides the method of obtaining the solution. This description, while more robust, nonetheless does not adequately involve the solver in its definition because it fails to consider the suddenness associated with an instance of insight.

This suddenness can be explained, in part, by the fourth perspective of insight as the removal of mental blocks – for example, impasses caused by functional fixedness. In the removal of a mental block we '[escape] the tyranny' (Gick & Lockhart, 1995) of our original interpretation, and overcome the impasse. We then experience exuberance because we have seen the problem's gimmick, and avoided it. Unfortunately, this definition of insight implies that solutions are already in the mind, waiting to be revealed, and that if the solver could remove the barrier they would achieve insight. Such is often not the case, as solvers frequently note that it was the lack of a key piece of knowledge, (Seifert *et al*, 1995) and not a block *per se* that prevented insight.

Finally, the notion of finding a problem analogue serves as perhaps the best of the five quasi-definitions of insight – namely, during problem solving we experience insight when we discover an analogous problem, or we see that the method of how to solve one problem can be applied to the current one. This view does the best job at both defining insight, and explaining the phenomenon of suddenness, that is, when an analogue is found, the method of solution appears quickly, because it was already there in the analogous one. All that need happen is a mapping of the problem elements. Nevertheless, this idea of finding a problem analogue is stretched when applied to many so-called insight problems. The finding of an analogous problem appears to be more appropriate as an explanation for insight (Chen & Daehler, 2000) rather than a definition. Analogous problems can aid in the formulation and interpretation of future problems, reducing the need for insight, and causing similar problems to become more routine (Chen and Daehler, 2000).

So perhaps a simpler, less contrived definition is what is needed. Seifert *et al* (1995) provide such a definition in quoting *Webster's New World Dictionary*, namely 'seeing and understanding the inner nature of things clearly, especially by intuition'. This description, however, is plagued by the most serious problem of the previous ones: it is far too general. It would be difficult to apply to the classification of problems, and is completely reliant on the concept of 'understanding', an equally obscure concept.

Alternatively, Steven Smith (1995) proposes to define insight by making a distinction between '*insight*, *insight experience*, and *insight problem*' (emphasis in original). This is a useful approach, for it may help to reduce 'insight' to its constituent elements. However, even with this more precise approach, he defines insight as 'an understanding'. He goes on to define the insight experience as 'the sudden emergence of an idea into conscious awareness, the "Aha!" experience' (Smith, 1995). Finally, in what one hopes would be a *coup de grace*, he defines the insight problem as 'one for which the solution is more likely to be reached via an insight experience'. One cannot help but feel let down.

These definitions do not satisfy the criteria of usefulness and precision. While insight is often described as an 'understanding', insight problems are likewise defined subjectively, in reference to an experience felt by subjects when finding the solution to a problem. Thus, the problems used to study insight are not problems that have been developed theoretically but instead by trial and error. Problems are found (mainly from previous studies, see Weisberg, 1995, pp 184-191), and subsequently classified as insightful by the Aha! effect they have when their solution is found, rather than the other way around. As Robert Weisberg notes, this method shows that ‘the classification system has no theoretical grounding’ (1995).

Other definitions of insight and classifications of insight problems are equally obfuscatory and circular (*e.g.* Sternberg and Ben-Zeev, 2001 or Gilhooly, 1988). This causes us to return to our first, and what will be called ‘simple’ definition of insight. It is ‘a transition event in which “a problem solver suddenly moves from a state of not knowing how to solve a problem to a state of knowing how to solve it”’ (Schooler *et al*., 1995). The word *how* is key to this definition. Perhaps, instead of insight problems being a set of problems that use some special process (for example Seifert *et al*., 1995), they are merely problems for which, following initial attempts to solve the problem, the solver realises they do not know *how* to solve it. One may even remove ‘sudden’ from the definition. In other words, insight is the discovery of a method to solve a particular problem where one was not previously known.

So how does this definition account for the suddenness or ‘Aha!’ experience? In problems in which insight does not occur, the solver either already knows how to solve the problem, or fails to solve it. However, in the group that tries to solve a problem persistently, the goal and solution states of the problem become very familiar. Thus, they develop a good understanding of their impasse: they do not know how to solve the problem, but are aware of the missing link. When they finally think of the alternate approach (how they do is an issue of explanation) they are already familiar with their goal, and so can easily solve the problem. This causes the solution to appear suddenly and assertively: the solver is certain that they now know how to solve the problem, thus leading to a feeling of contentment.

Hence, this emphasis on *how* to solve rather than *what* to do once *how* is known is what sets insight problems apart from conventional problems. In conventional or 'routine' problems, the solution method is already obvious, and the solver has merely to proceed through the steps. Purely insight problems might then be referred to as meta-problems, for they are problems on a higher level. For the purest insight problems, the steps are trivial (unlike, for instance, mathematical integration), and it is this 'meta' aspect of the problem that must be overcome. This is why problems such as the mutilated checkerboard problem (Appendix A, 1), are easily solved once a different method (other than brute-force confirmation) is applied.

In fact, this interpretation of insight can be applied to many classical insight problems. The nine-dot problem (Appendix A, 2) can now be seen to be a problem where the initial or intuitive method of solution is to stay within the 'box' created by the nine dots. This explains why, when insight is experienced, the solution is still not instantaneous, and steps must be worked out even after insight occurs. Thus, instructing subjects that the proper solution method was to leave the square matrix 'did not significantly facilitate solution' (Weisberg, 1995). This can now be attributed to the subject's having understood the method, but still needing to iterate through the steps to arrive at the solution.

Fixation can now be attributed to an inability to form a new method of solution, rather than an impasse in a correct solution method. Thus, functional fixedness on the typical use of pliers in the classical two-string problem (Appendix A, 7) causes an inability to see that the correct solution method is to cause the strings to move toward the subject, rather than the other way around. The steps involved once the correct method is established are now trivial.

This definition also fits nicely with the interpretation that insight is 'restructuring'. Seeing a problem in a new way, is, at its essence, looking at a problem and seeing a different method for solving it. The concept of the reformulation of a problem is now taken care of, as it is simply a change in how a solver approaches a problem, i.e. a different method of solution.

Another benefit of the simple definition is that it gives a deeper perspective on the empirical warmth ratings performed by Metcalfe (Davidson, 1995). Whereas Metcalfe had subjects judge their warmth on a scale of zero to ten for both insight and incremental problems, according to the simple definition of insight, this would lead to a mismatch between the two graphs (Figure 1). Thus, in incremental problems, the subjects would be starting their solving at a different, more advantageous state than in insight problems: they already know how to solve it. If the warmth rating had a value representing when the subject was confident in their method (five, say), it would be seen that in incremental problems, the subject has a higher rating from the get-go. This would be seen in contrast to insight problems, where the subject's progress in developing a method of solving the problem would be charted below the value of five.

The insight problem and incremental problems presented above are the types of problems given in many studies of insight problems. The incremental problem is typically a routine problem that the subject can confidently solve, but involves a number of steps. The insight problem, on the other hand, is one in which once a method for finding the solution is found, the steps needed to solve the problem are few (thus the quickness once the method was found). Interestingly, a method for classifying insight problems might be a test of its conduciveness to having the answers given in a multiple-choice fashion. By the above criteria, pure insight problems would involve no 'working out', and thus an answer, once shown, would appear self-evident. Insight problems may have the important property of being unable to test by multiple-choice.

This analysis in its own right suggests a different method of analysing potential problems, namely: the problem should be looked at in terms of the difficulty in developing the solution method, as well as another examination of the number of steps needed to solve the problem once it has been correctly formulated. This implies a radical concept: perhaps problem difficulty can be represented in two dimensions, where one axis represents the steps involved in solving a problem, and the other represents the meta-problem aspect, or finding the way in which to solve the problem. The routine method dimension involves effable problem solving, while the other dimension involves ineffable problem solving (Wieth & Burns, 2000). Although the experimental implications of this approach are tantalising, further speculation would be aimless.

Applying the dimensional perspective to problems such as the nine-dot problem is congruent with the findings of a number of researchers: the problems involve two aspects, and thus could be called hybrid problems (Weisberg, 1995). On the other hand, problems such as the Dunker radiation problem (Mayer, 1995) could be seen to be nearly purely insight, as the number of steps involved once multiple converging rays have been considered are very few. Furthermore, other problems that are normally seen as insight problems become, instead, exploits of interpretation (Weisberg, 1995), with little connection to reality. As Weisberg puts it, to say that 'one has "solved" the animals in pens (Appendix A, 3) problem by building four concentric pens, with all the animals in the middle one, violates the meaning of the phrase *four pens*.' He calls the solution, instead, one pen with four fences. The problem ceases to be an insight problem, and becomes instead a play on words, with all the difficulty now attributable to rationalisation and common diction. The solution involves a distorted interpretation that is not found in normal usage (Weisberg, 1995).

The same applies to the checker games problem (Appendix A, 4), as two men would never be referred to in such a way in natural speech without the implication that they were playing against each other. Similarly for the lazy policeman problem (Appendix A, 6). Driving was implied by the extra information, since references to one-way streets and rail crossings would not be made for a pedestrian in the first place. For the Charlie problem (Appendix A, 5), the issue is more one of a lack of information, as in reality Charlie's cause of death would have been plainly obvious (not to mention the fact that there is really no 'right' answer). This runs contrary to Gick and Lockhart's (1995) position that these artificial misinterpretations constitute pure insight. It is because these misinterpretations are contrived through deliberate misleading by the problem poser that the problems approach perversity and lose their ecological validity.

So how does one go about creating new insight problems? It seems that in actuality there are no problems that will require insight ability in everyone – for if the solver's original formulation of the problem is correct, the problem be solved in a routine fashion (Weisberg, 1995). As well, since it is possible to train subjects to perform better on certain types of insight problems (Kershaw & Ohlsson, 2001), the ability to generate new methods of problem solving will cause the classical problems to become useless. It thus seems unlikely that there is any such thing as a universal insight problem, since, for instance, while one person may have no idea how to solve the mutilated checkerboard problem, a mathematician may see it as a routine topology exercise.

The languishing state of insight research will not improve without a precise definition of insight, and more importantly, a robust and dynamic way of developing insight problems. Current research is inherently flawed because it uses problems that have little theoretical foundation. A new approach must be taken in all avenues of insight research, from empirical warmth-ratings to taxonomic systems for judging a problem's difficulty, contingent on a solver expertise. Without an exact definition of insight and insight problems, it will likely never be a rigorous sub-domain of cognitive science.

References

Chen, Z., & Daehler, M.W. (2000). External and Internal Instantiation of Abstract Information Facilitates Transfer in Insight Problem Solving. *Contemporary Educational Psychology, 25.* 423 – 449.

Davidson, J.E. (1995). The Suddenness of Insight. In R.J. Sternberg & J.E. Davidson (Eds.), *Nature of Insight.* (pp 125 – 155). Cambridge: MIT Press.

Dominowski, R.L. & Dallob, P. (1995). Insight and Problem Solving. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 33 – 62). Cambridge: MIT Press.

Duncker, K. (1945). On problem solving. *Psychological Monographs, 68(5),* whole no. 270.

Finke, R.A. (1995). Creative Insight and Preinventive Forms. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 255 – 280). Cambridge: MIT Press.

Gick, M.L., and Lockhart, R.S. (1995). Cognitive and Affective Components of Insight. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 197 – 228). Cambridge: MIT Press.

Gilhooly, K.J. (1988). *Thinking: Directed, undirected, and creative.* San Diego: Academic Press

Kershaw, T.C. & Ohlsson, S. (2001). *Training for Insight: The Case of the Nine-Dot Problem.* Paper presented at the Twenty Third Annual Meeting of the Cognitive Science Society.

Mayer, R.E. (1995). The Search for Insight: Grappling with Gestalt Psychology's Unanswered Questions. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 3 – 32). Cambridge: MIT Press.

Perkeins, D.N. (1995). Insight in Minds and Genes. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 495 – 533). Cambridge: MIT Press.

Schooler, J.W., & Melcher, J. (1992) The Ineffability of Insight. In R.A Fink, T.B. Ward, & S.M. Smith, *Creative Cognition: Theory, research and application.* (pp 97-134). Cambridge: MIT Press.

Schooler, J.W., Fallshore, M., & Fiore, S.M. (1995). Epilogue: Putting Insight into Perspective. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 559 – 587). Cambridge: MIT Press.

Seifert *et al*. (1995). Demystification of Cognitive Insight: Opportunistic Assimilation and the Prepared-Mind Perspective. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 65 – 124). Cambridge: MIT Press.

Smith, S.M. (1995). Getting into and Out of Mental Ruts: A Theory of Fixation, Incubation, and Insight. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 229 – 251). Cambridge: MIT Press.

Sternberg, R.J. & Ben-Zeev, T. (2001) *Complex Cognition: The Psychology of Human Thought.* New York: Oxford University Press.

Weisberg, R.W. (1995). Prolegomena to Theories of Insight in Problem Solving: A Taxonomy of Problems. In R.J. Sternberg & J.E. Davidson (Eds.), *The Nature of Insight.* (pp 157 - 196). Cambridge: MIT Press.

Wieth, M. & Burns, B.D. (2000). *Motivation in Insight versus Incremental Problem Solving.* Paper presented at the Twenty Second Annual Meeting of the Cognitive Science Society, Philadelphia, Pennsylvania, August.

Appendices

Sample problems (Source: Weisberg, 1995, pp 184 – 191, except where noted)

1. **Mutilated Checkerboard problem:** An 8 x 8 chess board has two of its diagonally opposite corners removed. Would it be possible to fit dominoes on every space of the board, where a domino covers exactly two adjacent chess board squares? Why or why not?
   Solution: Once it is seen that every domino must cover a black and a white piece, the fact that two pieces of the same colour are removed implies that 31 dominoes must cover a field with 30 squares of one colour, and 32 of the other. But the dominoes always touch an even number of either colour, therefore the dominoes could not cover the whole board. (Gick and Lockhart, 1995)

2. **Nine-dot problem:** Without lifting your pencil from the paper, connect the nine dots by drawing four straight lines (Figure 2).

3. **Animals in pens:** Describe how you can put 27 animals into four pens so that there is an odd number of animals in each pen.
   Solution: Make four concentric pens and put all 27 in the center pen.

4. **Checker games:** Two men play five checker games and each wins an even number of games, with no ties. How is that possible?
   Solution: The men did not play against each other.

5. **Charlie:** Dan comes home from work and finds Charlie lying dead on the floor. Also on the floor are some broken glass and some water. Tom is in the room too. Dan takes on look around and immediately knows how Charlie died. How did Charlie die?
   Solution: Charlie, Dan's pet fish, died of lack of oxygen when Tom, Dan's cat, knocked over the fishbowl, causing it to shatter and spill its contents.

6. **Lazy policeman:** A woman did not have her driver's license, with her. She failed to stop at a railroad crossing, then ignored a one-way traffic sign and traveled three blocks in the wrong direction down the one-way street. All this was observed by a policeman, yet he made no effort to arrest the woman. Why?
   Solution: The woman was walking.

7. **Two String Problem:** Subjects must tie together the ends of two strings suspended vertically from a ceiling, even though the strings are widely separated and cannot be grasped simultaneously at the outset. A number of objects are provided, including a pair of pliers (typically).
   Solution: Often, subjects are fixated on the typical use of the objects, which is useless. However, the simplest and unintuitive solution is to attach an object (often the pliers) to one string to act as a pendulum. The subject swings the weighted string, and then takes the end of the non-weighted string to the middle of the space between the two strings, pausing to wait until the "pendulum" arcs back toward the subject (Seifert *et al*, 1995).

Figure Captions

Figure 1.

Figure 2. The nine-dot problem and its solution.

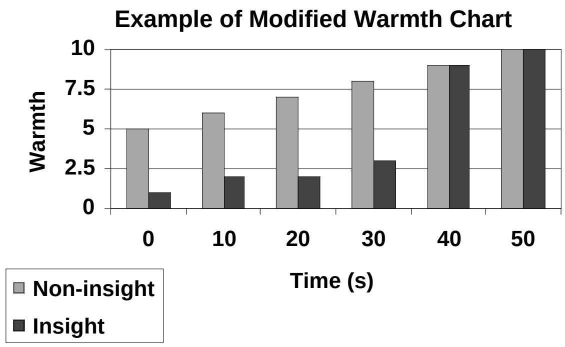

Figure 1.

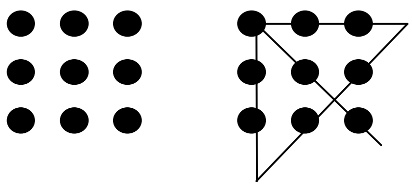

Figure 2.

Feature Distance in Consonantal Slips of the Tongue -

Psycholinguistic and Methodological Aspects

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Abstract

This paper deals with contextual phonological errors in a corpus of elicited German slips of the tongue. Emphasis is laid upon the analysis of the role of feature distance in contextual phonological errors. It turns out that feature distance is an essential factor determining phonological errors. From a methodological point of view, we tried to determine which of two feature systems is more appropriate to analyze and describe such errors, namely that of Kloeke (1982) or the IPA. Some criteria of evaluation were worked out. The vast majority of errors are one-feature errors. Additionally, the relation of feature distance and syllable distance between target and intruder segment is analyzed in detail.

Introduction

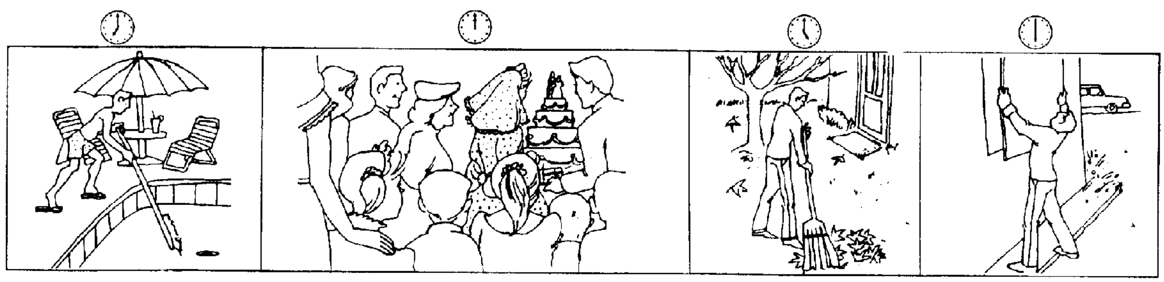
This study was carried out within a research project by the German Science Foundation (Deutsche Forschungsgemeinschaft (DFG)) on modality dependent and independent aspects of language production in the scope of the DFG main focus "language production".[1] In this project, slips of the tongue and hand are compared in order to assess modality dependent and independent effects in language production. There exist two parallel corpora, one for errors of Spoken German, and one for errors of German Sign Language (Deutsche Gebärdensprache (DGS)). In the following, I will only consider the spoken phonological consonantal slip data.

In particular, we investigate the role of feature distance in contextual phonological slips which seems to be a crucial factor determining this error type. For segmental errors, the phonological similarity of error and intruder element is well-documented. There is a large degree of consent concerning the result that segments tend to be phonetically similar if they interact in a speech error (van den Broecke and Goldstein, 1980, Ellis, 1980, Garcia-Albea, del Viso & Igoa, 1989, MacKay, 1970, Shattuck-Hufnagel, 1979, 1987, 1992, Shattuck-Hufnagel & Klatt, 1979). Especially, van den Broecke and Goldstein (1980) compared four feature systems in order to find out which of them is the most appropriate to analyze phonological errors. Due to the fact that speech errors are production phenomena in the first place, they reflect systematic properties which depend on the language processor. It seems to be obvious that the language processor tends to incur itself with cognitive load which is as small as possible. Consequently, a feature change of only one feature should be less expensive for the system than errors with a higher feature change. With respect to these speculations, we searched for the most adequate feature system being able to explain essential principles of phonological language production processes.

[1] This project (LE 596/6-3) is based on a grant to Prof. Dr. Helen Leuninger.

Method

The slip data were not accumulated in the traditional paper-and-pencil fashion but rather elicited by means of a more restricted experimental method. The deaf and hearing subjects were asked to sign or to tell, respectively, 14 picture stories under seven cognitive stress conditions. The picture stories vary in length and condition. There are seven short and seven long picture stories each of which are combined with one or two of these seven stress conditions. The following illustration shows one of the 14 picture stories.



The subjects were video- and/or audiotaped, a method which guarantees a higher degree of reliability than the usual slip collections. As opposed to the traditional paper-and-pencil method which leads to some extent to biases, the method described above provides bias-free corpora by virtue of the objective experimental procedure.

The two dependent variables are the slips of the tongue as well as the corresponding corrections. By additional cognitive stress conditions the error rate is increased; the probability of producing a slip of the tongue amounts to 0,73%. By contrast, Fromkin predicts a probability of 0,01% (Fromkin, 1980).

Classification of slips of the tongue

In total, we elicited n=944 slips of the tongue which can be classified in twelve different types of error as follows.

type of error	N	%
Anticipation	184	19.49
Perseveration	214	22.67
Harmony	48	5.08
Substitution	56	5.93
Semantic	156	16.53
Formal	31	3.28
Sem. + form.	3	0.32
Blend	188	19.92
Fusion	1	0.11
Exchange	11	1.17
Deletion	43	4.56
Addition	9	0.95
Sum	944	100

Table 1: Type of error

The following table shows which entities can be affected. As can be seen easily, words are the most affected unit followed by phonemes. But still, these findings are not exactly confirmed in the literature. Generally phonemes are considered being the most affected entity (Poulisse, 1999, p. 9). In spite of this difference, the frequency of phonemes is nearly as high as expected.

Affected entity	Sum	word	Phoneme	morpheme	phrase	grammtical feature	Semantic feature	others
Sum	944	328	285	108	151	66	2	4
%	100	34.74	30.19	11.44	15.9	6.99	0.21	0.42

Table 2: Affected entity

Phonological errors and feature distance

The following section focuses on phonological errors (n=285) which were scrutinized for nearly all of the effects known from the literature, as summarized in Poulisse (1999). In particular, we investigate feature distance as a factor determining contextual phonological errors such as anticipations and perseverations. In the literature, the research starts with the observation that consonants only interact with consonants and vowels only interact with vowels which is caused by the smaller feature distance in both cases and the same syllable position. Thus, it has been found that onsets interact with onsets, nuclei with nuclei, and codas with codas. This “syllable position contraint” is one of the strongest effects reported in the slip literature (Poulisse, 1999). It is assumed that the more similar two segments are the more likely they are to be substituted in a speech error. There are various studies which have shown that most phonological errors differ in only one feature from their target segment (van den Broecke & Goldstein, 1980, Klein & Leuninger, 1988), the most affected one being the place-feature. Note that this paper mainly concentrates on consonantal phonological errors.

In order to find out if our data can verify the findings stated in the literature, we examine contextual phonological errors such as anticipations or perseverations. We only take into account such errors which are considered to be phonological substitutions. Otherwise it is not possible to calculate the feature distance. Therefore unmotivated formal substitutions, deletions, and additions are omitted. After excluding these data, there remains a set of n=172 consonantal errors.

Besides this, there are methodological issues related to the feature systems which we used for computing the feature distance. We want to find out which among competing feature systems is the most appropriate one to characterize our data. In order to assess the appropriateness of the feature systems we compare the two most common ones, namely the International Phonetic Alphabet (IPA) and the one Kloeke (1982) and also Wiese (1996) proposed for German. As will be shown, the determination of the feature distance varies depending on the feature system.

Determination of the feature distance according to the IPA

The IPA system distinguishes three major features, namely place, manner, and voice. Place is divided into eleven subfeatures (bilabial, labiodental, dental, alveolar, postalveolar, retroflex, palatal, velar, uvular, pharyngeal, glottal), manner is separated into eight subfeatures (plosive, nasal, trill, tap/flap, fricative, lateral fricative, approximant, lateral approximant), whereas voice is a binary feature, which has one of two values, indicated by + and –, respectively.

THE INTERNATIONAL PHONETIC ALPHABET (revised to 1993, updated 1996)

CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible

Figure 1: Classification of consonants according to the IPA

We investigated n = 172 phonological errors with regard to one- to three-feature changes. With the IPA coding, we obtain 120 one-feature changes (69.76%), followed by 41 two-feature changes (23.83%) and only 11 three-feature changes (6.39%). The findings correspond with other results found in the literature. Although maximally 516 (170x3) feature changes are possible overall to be made, there are only 235. This means that only 45.5% of the potential changes actually occurred. From a statistical viewpoint, this may be seen as a first hint that only a small part of the possible changes is exhausted. The next diagram shows the distribution of one-, two-, and three-feature changes.

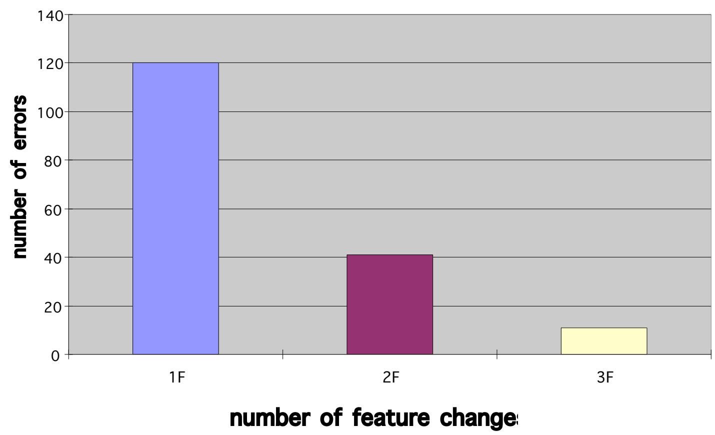


Figure 2: Number of 1-3 feature-changes

This distribution demonstrates that one-feature changes occur most frequently. Especially in the case of one-feature changes, place stands out compared with manner and voice. Strikingly, there is a high number of one-feature changes due to frequent m/n substitutions (n=33). Both [m] and [n] are nasals, but differ in the place feature bilabial and alveolar, respectively. 28 out of 33 m/n substitutions occur in the coda which leads to the assumption that in this case the feature distance interacts with the syllable position. The remaining 51 place features are distributed nearly equally with regard to onset and coda.

Considering the two-feature changes it turns out that place remains the most affected feature. However, in this case it co-occurs with the manner feature. This result will be discussed below. Table 3 summarizes the prevalence of place, manner, and voice in 1-, 2-, and 3-feature errors.

1-feature changes			2-feature changes			3-feature changes		
P	M	V	P	M	V	P	M	V
84	20	16	39	29	14	11	11	11
120 (120 errors)			82 (41 errors)			33 (11 errors)		
70%	16.6%	13.3%	47.6%	35.1%	17.1%	33.3%	33.3%	33.3%

Table 3: Feature distance in consonantal errors

Now, the question arises why it is the place feature which is affected mostly. According to the IPA system, place comprises eleven subfeatures. Thus, it is the most differentiated feature within the IPA. The more features are available in the set of place subfeatures the higher is the probability of a mis-selection. However, this cannot be the only explanation for the frequent occurrence of the place feature because manner also contains an extensive set of subfeatures. Recall that there are eight manner features. In spite of this, the manner feature is considerably less affected than the place feature. Actually, the number of single feature changes for both manner and voice is nearly equal (20 manner-errors vs. 16 voice-errors). Recall that voice contains only two specifications.

Another possible explanation may be the neural representation of the place features. Whereas place-features are organized in a single dimension (front-to-back) in the vocal tract, they may be distributed in a completely different manner within the brain. Assuming the fact that the place features are arranged on a topological cortical map in a certain way, it is conceivable that they are represented very closely to each other according to the close arrangement in the vocal tract. Lotze et al. (2000) have shown that during articulating the syllables /pa/, /ta/, and /ka/ various representational locations in the motoric cortex and the sensory cortex are activated. However, the representation of the manner-features is supposed to be more distinguished than that of the place-features. For instance, a plosive differs from a nasal to a higher degree than a bilabial feature from a labiodental feature does. Whereas plosives are made by releasing the airstream all of a sudden which causes an explosive sound, nasal sounds are produced by lowering the velum so that the air is released through the nose. That makes a great difference. In contrast to this, place features are determined by the position of the tongue in the vocal tract by which the air-stream is obstructed in the production of a consonant. As already mentioned above, the position of the tongue varies only little which can lead to the selection of the wrong place-feature.

A third explanation could be that segments are underspecified for the place features. Whereas segments are specified for manner and voice, the place feature is inserted in dependence of the phono-logical context as soon as the phonological processes start off. Still, the disadvantage of this assumption is that segments are not substituted due to their phonological context generally but rather due to their small feature distance and syllable position.

Only in a two-feature error it is possible to find out pairs of features which prefer to interact with each other. Even in such cases the place feature is the most affected one. Thus, this feature plays a crucial role. It most likely combines with manner (65.85%) and not with voice (29.27%) although the number of single feature changes for both manner and voice is nearly equal. As opposed to these findings, feature changes for both manner and voice hardly occur. Thus, this distribution shows a steep decline between the three (possible) feature combinations. The following table shows the feature combination in two-feature errors.

	Place x Manner	Place x Voice	Manner x Voice
	27	12	2
	65.85%	29.27%	4.88%

Table 4: Feature combination in 2-feature errors

A possible explanation for the frequent place-manner combination is that there is a higher number of both place and manner subfeatures whereas the voice feature is only binary. As a result, the number of possible feature combinations of place and manner increases. The following example (anticipation) shows a place-manner error.

(1) um an einer Hochzeits**t**ei//**f**eier teilzunehmen. (f → t)

in order to take part in a wedding ceremony

In this case the place subfeature changes from labiodental to alveolar whereas the manner subfeature fricative becomes plosive.

Place: [labiodental] → [alveolar]

Manner: [fricative] → [plosive]

The next example represents a place-voice error. This type of slip of the tongue is a harmony error that is that there are several intruder segments in the left and right context.[2]

(2) Dann ist der Kuchen fertig, kann mein **K**e// **B**esuch kommen. (b → k)

Then is the cake ready, can my visitors come.[3]

When the cake is ready, my guests can come.

In this case the place subfeature changes from bilabial to velar whereas [+voice] becomes [-voice].

Place: [bilabial] → [velar]

Voice: [+voice] → [-voice]

The following slip of the tongue (anticipation) shows one of the few manner-voice errors.

(3) Ta//natürlich (n → t)

Ta//naturally

[2] Segments which are candidates to be an intruder element have to occur as close as possible to the target segment. A slip of the tongue can be described as a harmony error only if there is an intruder segment in the left as well in the right phonological context showing the same syllable distance to the target segment. Because of this, in example (2) only [k] of "kann" and "kommen" can be regarded as potential intruder elements whereas [k] of "Kuchen" has no impact on the target phoneme.

[3] This is an interlinear translation of the slip of the tongue which shows the German word order. The same applies to the slip example on page 11.

In this case the manner subfeature changes from nasal to plosive whereas [-voice] becomes [+voice].

This kind of error only occurs rarely. Assuming that many segments are distinctive for manner, but not for voice one can conclude that manner and voice are not in the position to interact. E.g., nasals (m, n), approximants (j), laterals (l), and trills (R) are voiced in principle. Therefore voice does not occur as an independent feature. On the one hand these segments can change their manner feature, on the other hand they are not to be transformed from a voiced pronunciation into an unvoiced one.

Determination of the feature distance according to Kloeke and Wiese

As mentioned above, we aim at determining the most appropriate feature system in order to assess the feature distance. Whereas the IPA posits only three major features, namely place, manner, and voice, Kloeke's matrix comprises nine features: sonorant, back, high, low, high, coronal, nasal, continuant, and tense. All these features are specified as either + or -. Note that the feature [consonantal] can be ignored for our purposes. Besides, we do not exclude the feature [low], although not being distinctive for nearly all consonants. We include this feature because it is specified positively for the segments [h] and the glottis stop [¶] which we classify as consonants in accordance with Wiese (1996) but not with Kloeke. This seems to be an appropriate classification because both [h] and the glottis stop interact with other consonants, indeed, as in the following example.

Der Vater hat eine Di// [¶]Idee und schaut im Auto nach.

The father has an Di// idea and looks in the car after.

The father has an idea and looks into the car.

	m	n	_	l	R	p	b	f	v	t	d	s	z	_	_	_	_	ç	j	k	g	x
Cons	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Son	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Back	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+
Low	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
High	-	-	+	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+
Lab	+	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Cor	-	+	-	+	-	-	-	-	-	+	+	+	+	+	+	+	+	-	-	-	-	-
Nas	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cont	-	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+	+	+	+	-	-	+
Tense	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+

Figure 3: Feature system for consonants according toKloeke (1982) in Keller/Leuninger (1993: 29)

Apart from that, due to the syllable-position-constraint, vowels and consonants never interact. Therefore, consonants only appear in onset- or coda positions, respectively, whereas vowels only occur in the nucleus (Poulisse, 1999, p. 13).

By considering the Kloeke system we examine a number of 163 contextual phonological errors. Recall that the number of inquired errors with the IPA amounts to 172. This difference is caused by the uvular fricative as in „de**r**" (the, masc.) or „seh**r**" (very) which does not belong to Kloeke's feature system. Overall, there is a maximum of 1521 (169x9) feature changes. However, only 356 (23.4%) feature changes actually occur which indicates that there are only few feature changes per error. The distribution of feature changes is shown in the following table. Note that the figures in brackets refer to the number of feature changes whereas the others refer to the number of 1- to 9-feature errors (n = 163).

	1F	2F	3F	4F	5F	6F	7F	8F	9F
n: feature	53 (53)	53 (106)	37 (111)	15 (60)	4 (20)	1 (6)	0	0	0
%	32.52%	32.52%	22.7%	9.02%	2.45%	0.13%	-	-	-

Table 5: 1-9 feature changes according to Kloeke

According to Kloeke's coding, we obtain an equal distribution of one- and two feature changes (32.52%) and a constant decrease of increasingly distant errors.

Interestingly, errors changing more than six features do not occur. Thus, the maximal number of feature changes is not exhausted which leads to the assumption that the Kloeke system makes available too many feature changes (up to nine) which are not needed to accommodate the data. Regarding the frequency distribution of the nine consonant features there is no strong prevalence of one single feature.

	Son	Back	low	High	Lab	Cor	nas	Cont	tense
n	15	39	11	54	66	78	12	43	38
%	4.2	11	3	15.2	18.5	22	3.3	7.7	10.7

Table 6: Frequency distribution of the nine consonant features according to Kloeke

Because of the complexity of combinatorial possibilities, we did not investigate in which way the features prefer to interact with each other. Apparently, such a sophisticated feature system is not relevant for psycholinguistic issues, especially not for phonological processes as in slips of the tongue.

Comparison of the feature systems: IPA and Kloeke/Wiese

First of all, it is important to describe the differences between both the IPA and the Kloeke matrix in order to assess the outcome of the respective systems. Note that both the IPA and the Kloeke system do not correspond to each other in a one to one fashion.

The IPA is a phonetic system which defines the segments in a descriptive manner. It is for identifying and differentiating both phonemes and phonetical properties concerning all existing languages. By applying the IPA, it is possible to describe all segments which imply distinctive functions due to their different features. In contrast, the Kloeke matrix is a phonological system which derives specifications by applying phonological rules. The segments are characterized as feature bundles as in figure 3. E.g., “word-final devoicing” (“Auslautverhärtung”) is a phonological rule of German which describes the process leading from an underlying voiced segment ([d]) to a devoiced one ([t]) in the word final position as in “Kind” (child) → /kint/. By comparison, [d] in “Kinder” (children) is pronounced as [d]. Thus, [d] and [t] are two variants of one underlying segment. All feature specifications defining [d] and [t] are the same except for [tense].

Recall that the IPA is characterized by three major features, namely place, manner, and voice. The first two contain a multitude of subfeatures whereas only the latter one is binary. In comparison, the Kloeke system operates with nine binary features. The last-mentioned feature system contains features partially corresponding to subfeatures of place and manner in the IPA. Such a combination of different feature classes results in a hybrid system implying feature implications and redundancies within the system. For instance, the place feature of the IPA is divided into the features [labial], [coronal], [back], and [high], whereas the manner feature of the IPA is separated into the features [tense], [nasal], and [continuant]. Note that the feature [-sonorant] pertains to the class of obstruents which can be divided into plosives, fricatives, and affricates. The differentiation of these three features requires an additional classification by means of other features. Furthermore, the feature [-nasal] also has to be described by virtue of other features. Considering the feature [+continuant], it is comparable to the subfeature fricative of the IPA. Using the Kloeke system, it is necessary to apply a higher number of features in order to distinguish the segments than using the IPA. Note that it is not admissible to simply compare the results derived from phonological rules as in the Kloeke system with the descriptive phonetic feature determination by using the IPA. Both systems have been designed to serve different purposes. As stated in the introduction we are searching for that feature system which can characterize phonological errors by a minimum of feature changes. Our conjecture is: The less similar two segments are the more “expensive” it is for the system to change these features.

As the findings show, both systems attain a different distribution of the number of feature changes per error. In case of an m-n substitution, we obtain a two-feature change in the Kloeke system whereas this error is classified as a one-feature error in the

IPA system. Recall that there is a high number of m-n substitution which contributes to the different distributions. According to the IPA, the segments [m] and [n] differ in one feature, that is place. However, the Kloeke system needs two features, namely [coronal] and [labial] to indicate the difference between the two segments. Considering the feature substitution b-g within Kloeke's system, we even observe a feature change of three features, namely back, high, and labial. In contrast, using the IPA we obtain a one-feature error concerning place.

In spite of the differing results obtained by means of the IPA and the Kloeke system, respectivly, both of them show the same tendency: the more similar two segments are the more likely they are to be substituted in a speech error.

Concerning the decision of the most appropriate system in order to analyze phonological errors, we clearly prefer the IPA analysis. This system suffices with only three features which capture all actually occurring errors whereas the Kloeke system overgenerates by providing too many potential feature changes (up to nine) which are not needed to evaluate the data. The former system is able to compute the feature distance on phonological errors more easily due to its uncomplicated usage. In spite of this, the IPA is not less differentiated with respect to the characterization of feature changes. Rather, the detailed classification of features takes place on the level of subfeatures. Compared to the Kloeke system, the IPA is even more precise because the major features place and manner are subdivided in a more elaborated way. E.g. the feature coronal of the Kloeke system corresponds to four features (dental, alveolar, postalveolar, and retroflex) of the IPA. (The IPA contains six manner features refering to German, whereas the Kloeke systems comprises only three. In the same vein, the IPA contains eight place features accepted for German, whereas the Kloeke system comprises only four.)

Obviously, the single subfeatures are not relevant to determine the feature distance. It seems to be more suitable to explain phonological processes by applying the major features.

Interaction of feature distance and syllable distance

Presently, there are not many studies concerning the linear distance in contextual errors. Ellis (1979) found out that there is a syllable distance of maximally eight syllables between two exchanged segments. Moreover, Garrett (1980) found out that phonological exchanges take place between neighbouring words disregarding word classes, whereas word exchanges can occur across phrases but only affect words of the same word class. Thus, the former happen at a rather small distance; whereas the latter happen at a higher distance. These distinctions have lead to the assumption of two different processing levels on which word exchanges and phonological exchanges occur, namely the functional level and the positional level.

Additional to the feature distance, we also explored into the possible interaction of feature distance (according to the IPA) with syllable distance as a second determining factor of contextual phonological errors. Due to the syllable position constraint, the syllable can be used as the smallest unit with which the linear distance between target and intruder segment can be measured. Our hypothesis is the following: With increasing syllable distance between target and intruder segment, the feature distance is assumed to decrease. This is because both temporal distance and feature distance determine the likelihood of a phonological error. With increasing temporal distance and with decreasing feature similarity the likelihood of an error decreases overall. With increasing syllable distance only those intruder phonemes which are most similar to the target phoneme have a high enough impact to substitute for the target phoneme. Additionally, the greater the distance between the target and intruder segment, the higher the likelihood of there being such a similar phoneme.

In order to supply evidence for this assumption, we analyzed n=165 contextual consonantal slips of the tongue with regard to the distance between error and intruder element from 1 to >8 syllables.[4] Note that vowel errors, deletions, additions, substitutions, and harmony errors are omitted. The results are shown in the following table.

	Syllable distance	Feature distance
N: cases	165	129
∅	2.46	1.23

Table 7: Syllable distance in consonantal errors

Considering the 165 phonological errors, there is an average syllable distance of 2.46 syllables. This result indicates that contextual phonological errors occur in a small time window. The average feature distance of these errors amounts to 1.23 features. Moreover, this result points out that phonological similarity is a determining factor in phonological slips.

Determining the frequency distribution of errors with regard to the syllable distance (1 to 8), the structural measure yields the impressive result that most errors are only one syllable away from their intruder segments. The next table shows the resulting distribution which is illustrated by figure 4.

	1 S	2 S	3 S	4 S	5 S	6 S	7 S	8 S	>8 S	n: errors	n: syllables
n	70	48	20	6	6	7	1	3	4	165	406

Table 8: Syllable distance in contextual consonantal errors

[4] The structural analysis in terms of syllables is based on written transcripts of the slip sequences. We chose syllables as a structural measuring unit because they are prosodic units with a structure of their own which, however, is neutral with regard to the respective structure of words, morphemes, and segments. Recall that syllables do not figure as affected entities in slips. This is attributable to the fact that syllables are no planning units in the early production process but are generated ‘on the fly’ (Levelt, Roelofs & Meyer, 1999) in the very process of articulation. Concerning the measurement we start counting the syllable distance from the onset, nucleus, or coda of the intruder element to the respective onset, nucleus, or coda of the error element (but not including it). The direction of counting depends on the type of segmental error. In case of anticipations, the intruder element occurs to the right of the target element. Thus, it is counted from the right to the left. In case of perseveration the reversed counting method applies, i.e. it is counted from the left to the right.

The following discrete curve (fig. 4) can be characterized as a strictly monotonic and strongly decreasing function from one to four syllables. Beyond the distance of four syllables, the curve stays constantly on a low level. Interpreting the shape of the curve, one can conclude that phonological errors mainly occur within a time window from one to four syllables. The time window ends at the point where the curve does not continue to fall. Beyond the limit of four syllables, phonological errors are very rare. Overall, we agree with Ellis' findings (1979) that there is a maximal distance of eight syllables between target and intruder segment.

Estimating the duration of a syllable being 250 ms, phonological processes seem to take place within one second. In order to verify this assumption, we have carried out a temporal analysis of the distance between the intruder segment and the error segment. Noteworthy, the results confirm our hypothesis that phonological processes occur in a time window of one second.

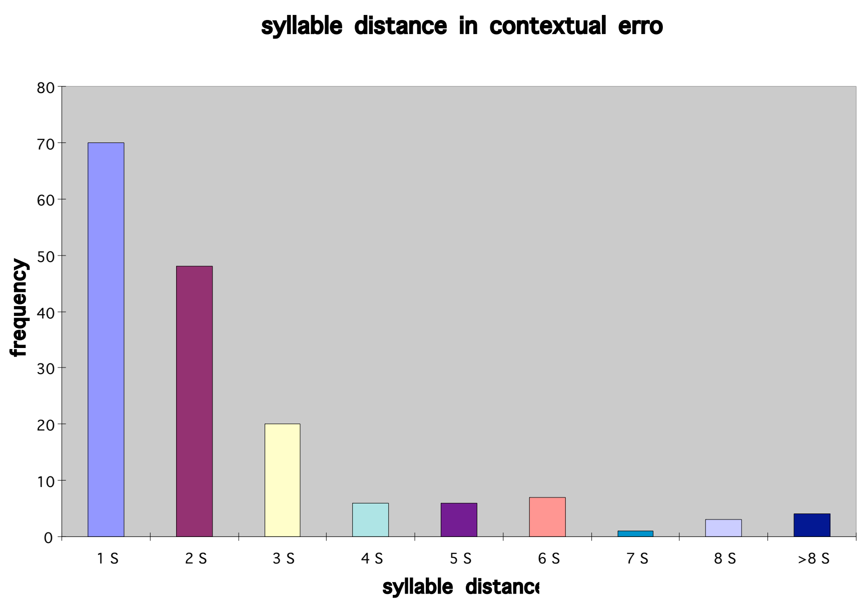


Figure 4: Syllable distance in contextual consonantal errors

Thus, phonological planning seems to be a strictly local process. Assuming as a thought experiment, that phonological processes took place within an extended time window of more than four syllables, the error rate would increase because more segments similar to each other would be available. Conceivably, a time window of four syllables represents an optimal temporal frame in which phonological processes are executed at a relatively low error rate.

In order to verify our hypothesis regarding the correlation of feature distance and syllable distance, we compared the two factors by computing the quotient. The following table shows the results.

	1 S	2 S	3 S	4 S	5 S	6 S	7 S	8 S	>8 S
Quotient	1,2	1,24	1,3	1,2	1	1,3	1	1,6	1,6

Table 9: Proportion of syllable distance and feature distance

There does not seem to be an interaction of the kind that the longer the syllable distance is the closer the feature distance is. Rather, the syllable distance stays the same despite increasing syllable distance. However, there are two restrictions concerning the syllable distance. Firstly, according to the IPA, there is only a small change of feature distance (up to three features) possible at all so that the differences between the syllable distances can hardly become statistically significant. Secondly, the feature distance exceeding eight syllables increases. This outcome is even contrary to our expectations. Possibly, errors with a distance more than eight syllables are no phonological errors at all. Rather, such kinds of errors are to be regarded as errors on the word level. Presumably, these few cases were misclassified.

Outlook

In conclusion, we want to emphasize that feature distance is a main determining factor of contextual phonological errors and thus highly relevant in the process of language production. We have pointed out that the most phonological errors show a feature distance of one. The more similar two segments are the more likely they are substituted for each other. Although we regard the IPA —on the basis of our results so far— to be the most appropriate one to determine the feature distance, the Kloeke system also demonstrates the tendency of the interaction of similar phonemes in a segmental error.

In spite of our clear results, it may be necessary to reconsider the findings drawn from the error analysis of the Kloeke system. As explained above, this feature system contains a certain number of redundancies. From a psycholinguistic point of view, it seems logical to hypothesize that the processor is able to compute the phonological implications automatically. This means that the lexicon does not contain redundant but only distinctive features. According to economical requirements of the lexicon redundant features are supposed to be derived automatically. What remains to be done is to reanalyze the phonological errors by considering the redundancies included in the Kloeke system. Feature changes which can be generated due to implications can be disregarded. Consequently, the number of feature changes is expected to decrease such that both the IPA and the Kloeke system should yield similar results.

Besides, the measurement of syllable distance defines the frame within which phonological processes take place. Note that pre-articulatory corrections concerning phonological errors can only be executed within the time window determined by the syllable distance between intruder and target segments. In structural terms, phonological errors take place in the time window of one to four syllables. Due to our audio-taped slip data we were able to carry out a temporal analysis in clock time. Based on this measurement we could verify the size of the time window of maximal four syllables which corresponds approximately to one second (Hohenberger & Waleschkowski, to appear).[5]

[5] The mean length amounts to 232 ms which is nearly identical to the usual estimation of 250 ms (Levelt et al., 1999).

By virtue of our objective experimental method we are able to draw valid inferences from our quantitative results to the actual phonological processes underlying human language production.

References

Ellis, N.C. (1979). Speech production and short-term memory. In: J. Morton & J. C. Marshall (eds.), *Psycholinguistics series, Vol 2: Structures and Processes*, London: Paul Elek/ Cambridge: MIT Press, 157-187.

Fromkin, V.A. (ed.) (1973). *Speech Errors as Linguistic Evidence*. Den Haag.

Fromkin, V.A. (ed.) (1980). *Errors in Linguistic Performance: Slips of the Tongue, Ear, Pen, and Hand*. New York.

Garcia-Albea, J.E., del Viso, S. & Igoa, J.M. (1989). Movement errors and levels of processing in sentence production. *Journal of Psycholinguistic Research*, 18, 145-161.

Garrett, M. F. (1980a). Levels of Processing in Sentence Production. In: B. Butterworth (ed.), *Language Production. Volume I. Speech and Talk*. New York: Academic Press, 177-220.

Garrett, M. F. (1980b). The Limits of Accommodation: Arguments for Independent Processing Levels in Sentence Production, In: Victoria A. Fromkin (ed.), *Errors in Linguistic Performance*. New York: Academic Press, 263-271.

Hohenberger, A. & Waleschkowski (to appear). Computational windows in language production: Words, morphemes, and segments.

Keller, J. & Leuninger, H. (1993). *Grammatische Strukturen*. Kognitive Prozesse. Tübingen.

Klein, M. & Leuninger, H. (1988). Gestörtes und nicht gestörtes Sprachverhalten. Zur Struktur lautlicher Fehlleistungen. *Frankfurter Linguistische Forschungen (FLF)* 4, 1-19.

Kloeke, W. van Lessen (1982): *Deutsche Phonologie und Morphologie. Merkmale und Markiertheit*, Tübingen.

Levelt, W. J. M, Roelofs, A. & Meyer, A. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 22, 1-75.

Lotze, M., Seggewies, G., Erb, M., Grodd, W. & Birbaumer, N. (2000). The representation of articulation in the primary sensorimotor cortex. *NeuroReport* Vol. 11, No 13, 2985-2989.

MacKay, D.G. (1970). Spoonerisms: The structure of errors in the serial order of speech. *Neuropsychologica*, 8, 323-350.

Poulisse, N. (1999). Slips of the Tongue. Speech Errors in First and Second Language Production. In Kees de Bot & Thom Huebner (Eds). *Studies in Bilingualism* (SiBil) Volume 20, Amsterdam, Philadelphia: John Benjamins.

Shattuck-Hufnagel, S. (1979). Speech errors as evidence for serial-ordering mechanisms in sentence production. In W. Cooper & E. Walker (Eds.), *Sentence Processing: psycholinguistic Studies presented to Merrill Garrett*, 295-342, Hillsdale, NJ: Lawrence Erlbaum.

Shattuck-Hufnagel, S. (1987). The role of word-onset consonants in speech production planning: New evidence from speech error patterns. In: E. Keller & M. Gopnik (Eds.). *Motor and sensory Processes of language*, 17-51. Hillsdale, NJ: Lawrence Erbaum.

Shattuck-Hufnagel, S. (1992). The role of word structure in segmental serial ordering. *Cognition*, 42, 213-259.

Shattuck-Hufnagel, S. & Klatt, D. H. (1979). Distinctive feature constraints on phoneme errors of different types. In *Proceedings of the ninth international Congress of phonetic Sciences, Copenhagen*, Eli Fischer-Jørgensen (ed.). Copenhagen, Institute of Phonetics.

Van den Broecke, M., P. R. & Goldstein, L. (1980). Consonant Features in Speech Errors. In: Fromkin 1980, 47-65.

Wiese, R. (1996). *The Phonology of German*. Oxford: Clarendon Press.

A NEW MODEL OF SIMILARITY

Finding the Essence of Similarity:
The Four Way Variance Model

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Abstract

The purpose of the present meta-analysis is to cross traditional discipline boundaries in order to integrate their findings and explore a new approach to the study of similarity. Previous research findings show that similarity judgments are complex and highly variable. With previous models, the understanding of similarity is as complex and variable as similarity itself. The author incorporates previous research findings from the disciplines of neuropsychology, developmental psychology, and cognitive psychology to develop a new model of similarity called the Four Way Variance Model. The paper concludes with an application of the model.

There is a constantly changing, infinite amount of perceptual information in the world. organisms who actively interact with and within this environment need to be able not only to perceive these perceptual cues, but they also need to be able to organize the infinite amount of information in some way. We live in a world where stimuli that are encountered once are likely to be encountered again (Zarate & Sanders, 1999), and often in a slightly different form. Human evolution has equipped us with the ability to both perceive our environments and to organize and remember past stimuli. The question of how we are able to do these things and thereby behave effectively in the world has intrigued many psychologists and cognitive scientists, sparking extensive research on the topic. Although these disciplines have developed a strong understanding of how our five senses perceive the world, an answer to how we organize and store the knowledge our senses bring to us is far less conclusive.

The initial goal of this paper was to develop an understanding of how humans use similarity to create categories and organize information from the external world. The first step in developing this understanding was an investigation of similarity. With established models of similarity, it became clear that this is an incredibly convoluted task. Rather than abandon the construct of similarity, the purpose shifted to an integration of previous research findings and the development of an alternate model for understanding similarity called the Four Way Variance Model.

VARIABILITY IN PAST SIMILARITY FINDINGS

It is currently believed that we organize knowledge into concepts, each one being a representation of a category in our mind. Concepts function to make sense of the huge amount of information that surrounds us by guiding our attention and by facilitating generalization, classification, inference, interpretation, and communication (Kunda, 1999). Specifically, classification allows us to make inferences on the basis of partial information (Medin & Coley, 1998). A category is defined by Medin and Coley (1998) as the set of entities picked out by the concept in a nonarbitrary manner. It is plausible that similarity, the degree of overlap between the respective properties of two stimuli, is the organizing principle for categories and categorization since "entities within the same category tend to be more similar to each other than they are to examples from contrasting categories"(Medin & Coley, 1998). This sentence fits with the natural understanding of similarity that everyone holds and uses in daily conversation. However, when you look beyond intuitive understanding, similarity quickly becomes too flexible to explain categorization and is better seen as its by-product rather than its cause (Medin & Ross, 1992).

Once you venture beyond intuitive understanding, the complex nature of similarity becomes apparent. It has been found that, depending on the level of analysis, any two things can be judged as arbitrarily similar or dissimilar (Medin & Coley, 1998). Formal models of similarity need to afford it great flexibility in order to account for the variability found in the research. To begin with, similarity judgments vary according to the goal of the categorization. Items will hold similarity insofar as there is a uniting purpose between them. The most well known example of this is Barsalou's (1991, cited in Ross and Murphy, 1999) work showing that children, money, and photo-albums are similar in that they are all items you would take out of a fire. Likewise, Medin, Lynch, Coley and Atran (1997) found that while taxonomists categorized trees according to morphological similarities, landscape workers categorized trees according to their similar functions in landscaping. The goals of both these groups, taxonomists and landscapers, influenced their respective similarity judgments.

Secondly, an individual's prior knowledge and area of expertise will vary the similarity judgments reached. Referring once more to the work of Medin et al. (1997), the differences in similarity judgments made by the taxonomists and the landscape workers can be attributed to the differences in expertise between each group. Furthermore, a dichotomy can be seen when novices or experts are given the task of sorting physics problems. Where novices group according to superficial similarity, experts group according to underlying physical principles (Chi, Feltovich, and Glaser 1981, cited in Kunda 1999).

A third point of variability is the context of the similarity judgment. Goldstone, Medin, and Halberstadt (1997) found that the similarity of two things depends greatly on the context of the judgment. This includes not only the alternatives available in the stimulus set, but it also includes the alternatives that had been presented on previous trials; prior alternatives will subsequently create a context for the later comparisons. They concluded that, rather than being fixed to physical properties a priori, salience of a dimension is modified "on line" at the time of the similarity judgment. Not only do the variables presented alter the context, but the way in which the question is phrased will also place a contextual constraint on the similarity judgment. Responses were found to vary with the direction of comparison required (How similar is A to B? verses How similar is B to A?) (Goldstone et al., 1991, cited in Soloman and Rips, 1998).

Ross and Murphy (1999) looked at the real world category of food in order to find how similarity judgments would be conducted for a domain that everyone had extensive experience with and which everyone found extremely personally relevant. They found that the contexts of other foods, the time of day, the setting, and other cultural indicators will each determine the ways which foods are grouped together and the categories that are activated.

A fourth variable of similarity is that individuals will not make similarity judgments that do not make semantic sense. Bassok and Medin (1997) found that when asked to judge similarity of paired stimuli, participants would integrate the stimuli into common thematic scenarios which would make sense of the stimuli. Semantic dependencies of the stimuli affected similarity judgments by inducing participants to systematically replace the process of comparison with that of association. In earlier work by Markman and Medin (1995), it was found that justifications of similarity judgments systematically favoured comparable over noncomparable properties. Participants did not willingly judge the similarity along nonsensical dimensions.

Furthermore, Wisniewski and Bassok (1999) articulated that in cases of comparison, the scenarios were from the same taxonomic category and were alignable (e.g. "we bought the Saturn because it is safer that the Dodge Neon"). In cases of integration the scenarios played different roles in a thematic relationship and were non-alignable (e.g. "the Saturn is safer than the car key”). Wisniewski and Bassok (1999) could not alter this pattern of similarity judgments with changes in the emphasis in questioning ("goes with" verses "is similar to") leading them to conclude that stimuli primarily affected the type of processing in the similarity judgment. In contradiction to this however, Yamauchi, Takashi, and Markman (2000) have found that category membership, not the stimuli themselves, affected the processing. They found category to influence inference even when similarity information contradicted the category label. Their findings suggest that category labels and category features are two different things

Finally, similarity is variable according to the salience of dimensions within the stimuli. Goldstone (1994, as cited by Sloman &Rips, 1998) has shown that when participants are told to make similarity judgments based on discrimination of visual patterns on one dimension, variation on an irrelevant dimension can slow them down. Likewise, Kaplan and Medin (1997) found similarity ratings to reveal a robust coincidence effect indicating that salience of a dimension varies similarity judgments. Coincidental exact matches on a salient dimension were weighed more heavily by participants than overall proximity in a similarity space. Kaplan and Medin (1997) do not, however, try to claim that coincidence is the mechanism of similarity, but rather that it is one type of similarity pattern displayed.

In conclusion, the flexibility of similarity is mediated by a number of variables including goals, prior knowledge, context, semantic coherence, and the relative salience of a dimension. This highly variable set of findings leaves the reader asking how coherence within the topic of similarity could possibly be found. The Modal Approach to similarity proposed that concepts are comprised of features and that two entities are similar to the extent that they share underlying features (Medin & Coley, 1998). This model of similarity has been criticized because it does not specify how the basis for this similarity is decided (Medin & Coley, 1998). The great variability found in the research reviewed above provides further support for this criticism. In Sloman and Rips's (1998) review of similarity they divide the views of similarity into four groups: strong similarity, weak similarity, feeble similarity, and no similarity. Each of these views vary in the degree to which similarity plays an explanatory role in categorization, from stating that similarity judgments are automatic and impenetrable to stating that similarity judgments are so complex that understanding them would require understanding whatever we are trying to use similarity to explain. Each of these views have supporting empirical data, especially the last one; similarity judgments are complex and highly variable. It is very tempting to throw up your hands to the variability found in the research and say that similarity will not be understood. Research could then turn to investigating the mechanism of categorization and concept development which we have been trying to explain with similarity.

How then, though, could we explain the fact that people make "similarity" judgments. Even experts in the area, who are arguably very conscious of "similarity", use the mechanism in their discussions in order to connect thoughts: "... taxonomic categories we investigated. *Similarly*, it is not known whether the basic categorization can be overruled by goal directed categories..." (Ross and Murphy, 1999). It appears that there is something to similarity which is unique in and of itself, and that similarity should not be dismissed.

A NEW THEORY: THE FOUR WAY VARIANCE MODEL

Part of the failure to develop a comprehensive theory of similarity is due to a lack of cross-disciplinary research. Sticking primarily to testing similarity by presenting semantic or visual stimuli and then coding the verbal responses has failed to break through the diverse empirical findings to form a unified theory of similarity. There is obviously something missing within the process of constructing the research and posing the questions to be investigated. In the research for this paper, neurological and developmental psychology findings were investigated alongside cognitive psychology. These areas emphasize the difference between implicit (outside conscious awareness) and explicit (within conscious awareness) tasks. Cognitive psychology makes a differentiation between procedural (that which can not be communicated verbally) and declarative (that which can be communicated verbally) knowledge. Together these distinctions can be combined into a two by two matrix to create four distinct areas where similarity judgments take place (Appendix A). By organizing cognition in this manner, it is much easier to be methodical in accounting for the variability in similarity findings. It is also possible to pose tasks in a way that would only test one of these four quadrants allowing the complexity of similarity to be explained more succinctly. This two by two matrix forms the Four Way Variance Model of Similarity (FWVM).

Support for the dissociation of implicit and explicit similarity tasks comes from neurological research. Very interesting data comes from patient LEW, reported in the work of Robertson, Davidoff, and Braisby (1999), who suffered a left hemisphere stroke leaving him with full visual fields, normal short-term spatial memory, and intact implicit categorization judgments. Despite these normal abilities, he failed significantly in tasks testing explicit categorisation judgments. He had no difficulty recognizing and interacting with objects, rather his problems appeared to be conceptual in nature. When given a colour sort task LEW grouped the colours in ways that were considered “illogical, paradoxical, or incoherent” (pg. 27), but he had no trouble choosing which colour was the odd-one-out. The same pattern of results was found for facial expressions. LEW could not make a categorization that required more than direct perceptual similarity. His knowledge about category boundaries is implicitly available for the task of eliminating one stimuli, but is not available for an explicit free sort task. Robertson et al. (1999) proposed that similarity is an umbrella term for two different types of similarity comparisons, some involving only perceptual attributes, and some involving category relevant information. This conclusion has been integrated into the FWVM, theorizing that implicit procedural similarity judgments would rely on perceptual attributes and explicit declarative judgments would use more category relevant information.

The selective degradation in LEW's abilities suggests that implicit similarity judgments are localized in different areas of the brain from explicit similarity judgments. Robertson et al. (1999) suggest that LEW's implicit perceptual categories are completely hard-wired into the visual system which was still intact after his stroke, and that these categories could be both acquired through experience and genetically coded from birth.

Additional neurological findings also support the theory of localization of similarity judgments within the brain. Mummery, Patterson, Hodges, and Price (1998) predicted that the processing of what an object looks like would be neuroanatomically dissociated from processing where the object is typically found. They found that the left temporo-occipito-parietal junction showed enhanced activity for similarity judgments about object location, and that the left anteromedial temporal cortex and caudate nucleus were differentially activated by colour similarity judgments. These results suggest that perceptual similarity judgments are fundamentally different from similarity judgments involving context. Later work by Price, Mummery, Moore, Frackowiak, and Friston (1999) found that the extrasylvian temporo-parietal and medial superior frontal regions are sufficient to perform semantic similarity judgments.

Recent work within cognitive psychology also supports a dissociation between implicit and explicit tasks. The research of Humphreys, Tehan, O'Shea and Bolland (2000) found proactive interference effects for cued recall tasks when the target words were "similar", but found no effect of "target similarity" on free association tasks. This research is flawed in that it uses a common understanding of similarity to choose "similar" target words without ever explaining why those words are considered similar. It is helpful, however, because it shows that implicit tasks vary from explicit tasks in that they are affected differently by proactive interference on the dimension loosely defined as "target similarity".

These results validate the need to separate the implicit tasks (like free association) from the explicit tasks (like cued recall) which have been widely used in similarity research. This differentiation may account for some of the variability found in the literature. The FWVM separates implicit and explicit tasks because they do not test the same neural pathways nor the same type of similarity judgments. At the right level of observation, future research may find that the four areas of the FWVM are each characterized by unique patterns of neural activation.

The second differentiation in the FWVM, that between procedural and declarative knowledge, was sparked by the work of Lockart, Layman, and Glick (1988) on insight problems. They differentiate between procedural and declarative knowledge in the transfer of concepts. Their research revealed that concept training within procedural knowledge, but not within declarative knowledge, facilitated future problem solving skills. There is therefore a difference between procedural concepts and declarative concepts. Since similarity is so closely tied to concepts and categorization, there may also be a difference between procedural similarity and declarative similarity.

The research reviewed at the beginning of this paper is based heavily on declarative responses which are inherently insufficient for understanding similarity due to the ineffable nature of many similarity judgments. Although individuals can justify their similarity comparisons, they can not state why, for example, they know that apples and oranges are extremely dissimilar and can be widely used as an exemplar of a bad comparison (Wisniewski and Bassok, 1999). Research within developmental psychology was reviewed in order to investigate the declarative-procedural dichotomy. A starting point into procedural similarity is to investigate the actions of preverbal infants who can not articulate their similarity judgments but rather can simply act on them. Quine (1977, cited in Mandler and McDonough 1996) found that generalizations in infancy were based on physical similarity in areas such as colour, shape, and texture. Recent work done by Gerhardstein, Adler, and Rovee-Collier (2000) has found that three month olds represent the specific size of an object and can discriminate that particular size from other sizes twenty-four hours later. When the task does not require reaching, it has been found that even newborns include size in their mental representations of an object (Slater et al. 1990, cited in Gerhardstein et al., 2000). The proficiency of infants to perceive the physical aspects of a stimuli supports the theory that physical characteristics are the primary basis for similarity judgments. This impact of direct perceptual similarity is evident in the structure of people’s naturalistic similarity theories (Medin and Ross, 1992).

Mandler and McDonough (1996) investigated categorization of perceptually similar categories in fourteen month olds. A very interesting finding from this research is that infants can not only classify on the basis of percept, but that they are also influenced by conceptual categories. The infants generalized across the entire category of animal no matter how perceptually diverse the stimuli were. They would then attend to an aeroplane as novel stimuli even if it was extremely perceptually similar to the bird included in the animal set. The same pattern of generalization was seen across the category vehicles, with a subsequent novel response to an animal added to the vehicle stimuli set. Not only did categories influence the infant's pattern of habituation to stimuli, but they also influenced the infants imitations of actions performed by the experimenter. Infants were reluctant to cross category boundaries to perform inappropriate actions. Mandler and McDonough (1996) concluded that there was more than one type of categorization taking place in infancy. Their results support both the theory that procedural concepts differ from declarative concepts, and the theory that procedural similarity differs from declarative similarity. Florian (1994) found that adults show the same pattern similarity judgments as children aged three to five on the declarative similarity judgment tasks she administered. It is not a far leap to hypothesize from these findings that adults would also show the same pattern of procedural similarity judgments as the infants tested.

APPLYING THE FOUR WAY VARIANCE MODEL

Now that the FWVM has been developed it should be applied to the variable findings regarding similarity. It allows for varying levels of perceptual similarity, semantic similarity, and cognitive concepts to interact when making a similarity judgment. FWVM therefore also allows for variance in the explanatory role of these factors (recall Sloman & Rips (1998) criticism that similarity shows varying levels of the explanatory role that it plays in categorization).

Implicit Procedural Similarity (IPS) accounts for results of perceptual similarity judgments, variance due to the salience of a dimension, and variance due to context. Since salience of a dimension and context are closely tied to perception they are included in the same quadrant. It should be noted, however, that Mummery et al. (1998) found that the percept of an object was processed separately from the context of the object. There is therefore more than one mechanism working in context analysis and context may also play a role in Explicit Procedural Similarity. IPS has the highest reliance on perceptual cues, and the lowest reliance on semantic similarity and higher cognitive concepts. These similarity judgments are quick and automatically acted upon without higher cognitive analysis.

Implicit Declarative Similarity accounts for the ineffable nature of many similarity judgment and categories. It is in this quadrant that prior knowledge and expertise plays a large role along with other high order cognitive concepts. These variables are included under implicit similarity because, for example, the physics expert categorizes based on underlying principles outside of conscious awareness. He would have to put cognitive effort into not categorizing in this manner, but he can easily articulate the final categorization.

Explicit Procedural Similarity is the least well defined category because the two terms generally contradict each other. It is not obvious how a similarity judgment could be made at a conscious level without then being vocalizable. An emphasis on procedural aspects needs to be made in that similarity judgments within this quadrant would result in actions not simply answers. It is in this quadrant that the variable of semantic coherence fits. Like infants who will not imitate actions inappropriate to the category (Mandler et al., 1996), adults will not make comparisons which are inappropriate to the coherent schema (Wisniewski & Bassok, 1999). Both these findings are procedural in nature.

Explicit Declarative Similarity is the most straightforward quadrant. If one were to be perfectly strict in categorizing the research findings most current results, aside from the developmental psychology results, would have to be placed within this quadrant. The vast majority of findings have been taken from verbal declaration of similarity comparisons which are within conscious awareness. The variance due to the goals of the individual is included here. Goals are the explicit uniting purpose to the similarity judgment and are used to answer questions like “What will I eat for breakfast?” (Ross et al., 1999). This quadrant contains the most variance due to cognitive concepts applied to the stimuli, and the smallest effects of perceptual and semantic similarity.

In both procedural quadrants, stimuli would primarily affect the similarity judgment as was found in the work of Wisniewski and Bassok (1999). On the other hand, in both declarative quadrants category structure would override similarity judgments as found by Yamauchi, Takashi, and Markman (2000). For a summary of how results fit into the FWVM please refer to Appendix B.

Although similarity has been intimately connected with research on categorization and it is this research which was focused on in this paper, similarity has also been connected with a wide range of theories including theories of reasoning, decision making, problem solving, and memory searches. Similarity has not yet offered insight to any of these theories, but rather has opened them to the criticisms which similarity receives. Without an accurate understanding of similarity, one can not provide further understanding to subsequent theories (Vervaeke, 2000). Going beyond intuitive understanding of similarity to find its essence is the challenge presented to researchers on the topic. Previous findings do not fit perfectly into the FWVM in part because the methodology of those experiments did not test one quadrant specifically, and in part because the model is not perfect. The model does however provide a framework through which research on similarity could become more methodical and thereby have more power to account for the variance in findings. The ability to account for the flexible nature of similarity would bring cognitive psychology closer to the essence of similarity.

References

Bassok, M., & Medin, D. (1997). Birds of a feather flock together: Similarity judgments with semantically rich stimuli. *Journal of Memory and Language, 36,* 311-336.

Florian, J. (1994). Stripes do not a zebra make, or do they? Conceptual and perceptual information in inductive inference. *Developmental Psychology, 30,* 88-101.

Gershardstein, P., Adler, S., & Rovee-Collier, C. (2000). A dissociation in infants' memory for stimulus size: Evidence for the early development of multiple memory systems. *Developmental Psychobiology, 36(4),* 123-135.

Goldstone, R., Medin, D., & Halberstadt, J. (1997). Similarity in context. *Memory and Cognition, 25(2),* 237-255.

Humphreys, M., Tehan, G., O'Shea, A., & Bolland, S. (2000). Target similarity effects: Support for the parallel distributed processing assumptions. *Memory and Cognition, 28(5),* 798-811.

Kaplan, A., & Medin, D. (1997). The coincidence effect in similarity and choice. *Memory and Cognition, 25(4),* 570-576.

Kunda, Z. (1998). Concepts: Representing social knowledge. *Social cognition.* London: The MIT Press, 15-52.

Lockhart, R., Lamon, M., & Gick, M. (1988). Conceptual transfer in simple insight problems. *Memory and Cognition, 16(1),* 36-44

Mandler, J., & McDonough, L. (1996). Drinking and driving don't mix: Inductive generalization in infancy. *Cognition, 59,* 307-335.

Markman, A., & Medin, D. (1995). Similarity and alignment in choice. *Organizational Behaviorand Human Decision Processes, 63(2),* 117 - 130.

Medin, D., & Coley, J. (1998). Concepts and categorization. In J. Hochberg (Ed.), *Perception and Cognition at Century's End* (pp. 403-430). New York: Academic Press.

Medin, D., Lynch, E., Coley, J., & Atran, S. (1997). Categorization and reasoning among tree experts: Do all roads lead to Rome? *Cognitive Psychology, 32,* 49 - 96.

Medin, D., & Ross, B. (1992). *Cognitive Psychology*. New York: Harcourt Brace Jovanovich College Publishers.

Mummery, C.J., Patterson, K., Hodges, J.R., & Price, C.J. (1998). Functional neuroantomy of the semantic system: Divisible by what? *Journal of Cognitive Neuroscience, 10(6),* 766-777.

Price, C.J., Mummery, C.J., Moore, C.J., Frackowiak, R.J., & Friston, K.J. (1998). Delineating necessary and sufficient neural systems with functional imaging studies of neuropsychological patients. *Journal of Cognitive Neuroscience, 11(4),* 371-382.

Roberson, D., Davidoff, J., & Braisby, N. (1999). Similarity and categorization: Neuropsychological evidence for a dissociation in explicit categorization tasks. *Cognition, 71,* 1-42.

Ross, B., & Murphy, G. (1999). Food for thought: Cross-classification and category organization in a complex real-world domain. *Cognitive Psychology, 38,* 495-535.
Sloman, S., & Rips, L. (1998). Similarity as an explanatory construct. *Cognition, 65,* 87-101.

Vervaeke, J. (2000, October). *Insight and the problem of transfer: Intuition, incubation, and ineffability*. PSY 370 H1F. University of Toronto, Toronto.

Wisniewski, E., Bassok, M. (1999). What makes a man similar to a tie? Stimulus compatibility with comparison and integration. *Cognitive Psychology, 39,* 208-238.

Yamauchi, T., & Markman, A. (2000). Inference using categories. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26(3),* 776 - 795.

Zarate, M., & Sanders, J. (1999). Face categorization, graded priming, and the mediating influences of similarity. *Social Cognition, 17(4),* 367-389.

Appendix A

	Procedural	Declarative
Implicit	Implicit Procedural Similarity	Implicit Declarative Similarity
Explicit	Explicit Procedural Similarity	Explicit Declarative Similarity

APPENDIX B

The Four Way Variance Model of Similarity Judgements

	Procedural	Declarative
Implicit	-highly guided by perceptual similarity **-salience of a dimension** **-context** -stimuli would primarily affect the similarity judgement	**-prior knowledge**: answers where the process to the answer is ineffable -where the knowledge is so well learnt that it now is activated automatically -category structure would override similarity judgements
Explicit	**-semantic coherence** **-context** -stimuli would primarily affect the similarity judgement	**-goals**: the explicit uniting purpose to the similarity judgement -highly guided by cognitive manipulation to apply category relevant information -answering questions like "What will I eat for breakfast?" -category structure would override similarity judgements

The Turing Test and Alternate Rationalities

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Abstract. Since the introduction of the imitation game by Turing in 1950, there has been much debate about the possibility of machine intelligence and the accountability of the imitation game as a test of intelligence. Despite its limitations as a test of intelligence, the imitation game is a small yet important step in freeing Artificial Intelligence from the unnecessary constraint of imitating human intelligence. Viewing human intelligence as one possible form of intelligence will enable AI researchers to seek alternate rationalities that will create richer ways of understanding intelligence.

Key words: Artificial Intelligence, Imitation Game, Turing Test, Chinese Room Experiment, Searle, Total Turing Test.

0. Introduction

Can machines think? The British mathematician Alan Turing tried to answer this question more than fifty years ago. His "Computing Machinery and Intelligence" paper (Turing, 1950) not only gave birth to a new field called Artificial Intelligence (AI), but it also fueled a great deal of debate among philosophers on the nature of the mind and intelligence.

Turing proposed his famous imitation game as a replacement for the question “Can machines think?” His intention was to bypass the mystery of intelligence by equating perplexing internal brain functions with more comprehensible outward behaviors. Turing’s functionalist approach to understanding the mystery of intelligence may initially be considered too simplistic and even useless. However, careful consideration of the imitation game reveals that in his functionalist account, Turing set the right direction for Artificial Intelligence, giving greater freedom for the development of modes of artificial rationality distinct from human rationality.

Instead of judging the validity of Turing’s imitation game as a test of intelligence, it is more useful to consider it as an attempt to liberate intelligence from the monopoly of human intelligence. Following Turing’s direction will provide us ample opportunity to understand the nature of intelligence, whether in human or alternate forms.

1. The Imitation Game and Its Implications

As the father of Computer Science and a talented mathematician, Turing passionately believed that intelligence was within the scope of computable operations. The first indication of his belief in machine intelligence goes back to as early as the end of World War II. In one of his statements in 1945 he says:

> Given a position in chess the machine could be made to list all the 'winning combinations' to a depth of about three moves in either side. This is unlike the previous problem, but raises the question 'Can the machine play chess?' It could be fairly easily made to play a rather bad game. It would be bad because chess requires intelligence. We stated at the beginning of this section [i.e. when describing how programming is done] that the machine should be treated as entirely without intelligence. There are indications however that it is possible to make the machine display intelligence at the risk of its making occasional serious mistakes. By following up this aspect the machine could probably be made to play very good chess. (Hodges, 1999, pp.30)

This statement indicates the path that Turing would follow five years later. In 1950 (Turing, 1950), Turing proposed a test called the imitation game which is also known as the Turing Test (TT). The game is initially played by three humans --a man, a woman and a judge. The only communication among the judge, the man and the woman is via teletype machine. The judge has to determine the gender of the person at the other end by only asking questions via teletype. But both of the players are trying to convince the judge that they are female. Now, imagine that one of the players is replaced by a machine and the task of the judge is changed. He now must distinguish between the human player and the machine player rather than distinguishing between genders. If the judge cannot make the distinction between the human and the machine player, then the machine is said to have passed the test. In other words, if the machine fools the judge to believe that it is a human, the machine passes the test.

According to Turing, passing the imitation game is enough to conclude that the machine is sufficiently like the man to be accorded the same intellectual status. In other words, "Can a machine think?" can be reduced to "Can a machine pass the imitation test?" The absence of a general definition of intelligence at the time enabled Turing to create a definition that further helped him to defend his intelligence test. He proposed "looks like a duck, walks like a duck, quacks like a duck, it's a duck" as the definition of intelligence (Siebel). He believed that we shouldn't worry about what's going on inside of the machine. What matters is the outward behavior and if it is indistinguishable from the outward intellectual behavior of a human then it is, by his definition, intelligent (Siebel).

The validity of the imitation game as an ultimate test of intelligence is still disputable. Nevertheless, it is the first major attempt to treat machine intelligence (and by implication human intelligence) functionally, independent of considerations of the body. Turing's imitation game can be thought of as an attempt to revolutionize the classic notion of intelligence, liberating our concept of intelligence from the monopoly of human intelligence.

2. Searle's Chinese Experiment & Simon on Computer Intelligence

Turing’s bias towards functionalism and the deep reductionism of the imitation game raised opposition among philosophers of mind. Among those opposed to the TT, John Searle was probably the most influential one. In "Minds, Brains, and Programs," (Searle, 1980) Searle introduces his famous "Chinese room" experiment. Searle wants us to imagine a man sitting inside a closed room. As input, he gets a piece of paper covered with Chinese symbols (squiggly marks as he refers to them) through a hole in the door. The man then looks at his big reference book that contains all the rules to match certain squiggly marks with other squiggly marks. So according to what input he gets, he looks at his book, finds the corresponding marks, writes them down and presents those marks as output from the hole of the door. Searle's point is that the man in the room can pass the TT. He can play the imitation game with a native Chinese speaker and he can fool the native Chinese speaker into thinking that he can speak Chinese. In truth, he has no understanding of Chinese whatsoever. All he does is matching inputs with corresponding outputs without any understanding. Searle takes this idea and concludes that intelligence is not simply a matter of computation or symbol manipulation as Turing suggests.

Searle not only refuses Turing's computational view of mind but he also claims that the imitation game is not really a test of intelligence. As convincing as it sounds, Searle's Chinese room experiment hasn't gone unchallenged. The most convincing reply, also known as the systems reply, came from computer scientists at Berkeley. According to the systems reply, although there is no understanding at the level of man in the room, there is understanding in the whole system. They claim that the room combined with the man and the rule book possesses some understanding. We don't deny understanding from a brain because of one single neuron's lack of understanding. So why should we deny understanding from the whole system because the man does not understand Chinese? Searle responds to the systems reply by letting the man memorize the rule-book and do all the manipulations in his head. Now the man is the system and he still doesn't understand. A possible answer to Searle's reply is following. “If it were really possible for the man to memorize all the rules and do all the manipulations in his head, then there could be a ‘passenger’ personality, an entity that is using the man's brain but is not the man, and who exists only because the man is doing the calculations prescribed by the rule-book” (Siebel).

Although it runs contrary to all intuition, Turing's imitation game is not so easy to refute. If a machine talks like a human, acts like a human, then on what grounds can it be denied of intelligence? Turing's imitation game is so basic that perhaps we feel reluctant to identify intelligence so simply. If intelligence can be identified functionally, how can we claim that we have a complex brain that produces miraculous and mysterious results such as reasoning and creativity? As Herbert Simon points out in his article "Machine as

Mind" “perhaps we are reluctant to give up our human uniqueness--of being the only species that can think big thoughts. Perhaps we have ‘known’ so long that machines can't think that only overwhelming evidence can change our belief.” (Simon, 1995, pp. 23)

In his article, Simon portrays minds as machines. He explains how seemingly mysterious aspects of our minds, such as selective heuristic search, recognition, semantics and insight problems, are actually not as mysterious as they seem. He draws on significant data from psychology to support his ideas. He claims that words like "intuition" or "creative" are not as human as they seem to be. For example, he defines "intuition" as problem solving by recognition and it can be easily modeled by production systems. He also talks about a "creative" computer program called BACON, which, when given the data available to scientists in historically important situations, has rediscovered Kepler's Third Law, Ohm's Law, Boyle's Law and many others. The following paragraph from his article is very interesting.

> It has been argued that a computer simulation of thinking is no more thinking than a simulation of digestion is digestion. The analogy is false. A computer simulation of digestion is not capable of taking starch as an input and producing fructose or glucose as outputs. It deals only with symbolic quantities representing these substances. In contrast, a computer simulation of thinking thinks. It takes problems as inputs and (sometimes) produces solutions as its outputs. It represents these problems and solutions as symbolic structures, as human mind does (Simon, 1995, pp.24)

Turing and Simon might be right. Maybe the human mind does not reach its goals mysteriously or miraculously. As Simon suggests, maybe “even its sudden insights and "ahas" are explainable in terms of recognition processes, well-informed search, knowledge-prepared experiences of surprise, and changes in representation motivated by shifts in attention.” Maybe the unexplainable is explained once we accept the fact that computers have been thinking "creatively" and "intuitively" for the past 35 years.

3. DeLancey's Passionate Engines

Even if we accept the "creative" and "intuitive" thinking of computers, one question still remains unanswered. Is the TT really a test of intelligence, and if so, of human intelligence or intelligence more generally? Before answering this question, we need to define what we mean by intelligence and intelligent behavior.

In his book *Passionate Engines* (Delancey, 2002), Craig DeLancey investigates the relationship between what emotions reveal about the mind and artificial intelligence. He shows that our best understanding of the basic emotions provides essential insights into key issues in the philosophy of mind and AI. He believes that emotions and behaviors are not completely unrelated. In fact, he asserts that emotions are inseparable from actions, which is why he refers to emotions as effects in his book. He offers new ways to understand the mind, suggesting that autonomy--and not cognition—should be the core problem of the philosophy of mind and AI.

When he reflects on the computational theory of mind, DeLancey claims that symbolic computational functionalism cannot account for the effects of some basic emotions. Hence he believes that functionalism as a theory of human and other animal minds is inadequate. In "Affective Engineering" a key section of his book, he reasserts the importance of autonomy and how it should be the central focus of AI. Delancey asserts that the idea of starting with a pure symbol or proposition manipulation, as modeled by a symbol manipulating language, and getting autonomous behavior out of this has been a failure.

He suggests viewing an intelligent system not as a mere symbol manipulator but foremost an autonomous passionate engine. We have little reason to think of the cognitive abilities that humans have as anything but one among many strategies for autonomy. Cognition is neither necessary nor sufficient for autonomy. His central thesis is the body and the mind, passion and action, are inseparable.

DeLancey's argument is very convincing because his analysis of mind situates mind in the context of nature and evolutionary history. Instead of trying to reduce intelligence to some sort of function or automata, he argues that we ought to enrich our understanding of intelligence by viewing it as manifested through the body. His introduces autonomy as a necessary condition for intelligence and supports his thesis by pointing out that many nonhuman animals reveal a high degree of autonomy to such an extent that they differ from us only in lacking comparable cognitive skills. He also believes that we have little reason to think of the cognitive abilities that humans have as anything but one among many strategies for autonomy. He links brain and body together so tightly that brain without body and intelligence without autonomy is unthinkable.

Delancey provides a new path for AI and following this path can *only* increase our knowledge and understanding of the potentiality of AI. Nevertheless, Delancey's conception of embodied intelligence might also be thought to restrict AI. As Delancey argues in his book, he expects to see robotics growing cheaper and more powerful in the future, and hence an essential part, if not the core, of AI in the future (Delancey, 2002). Delancey probably does not consider Deep Junior, a machine that won three chess games against the best human chess player, intelligent since it does not have a body. This approach might lead us to think that having a body is a necessary condition for intelligence. If AI's aim is to imitate human intelligence, then requiring a body for intelligence might be a necessity. However, if we want to simulate or create forms of intelligence in general, requiring a body for every intelligent agent will not help AI.

Passionate Engines completely eliminates the possibility that the TT can be an intelligence test for machines because the TT not only rests on the assumption that cognition is sufficient for intelligence but it also disregards the importance of autonomy and feeling in intelligence.

4. Is Turing Test Really a Test of Intelligence?

DeLancey brought autonomy and the inseparability of mind and body into efforts to define intelligence, and pointed to biology as a proper guide for AI rather than physics or mathematics. Embracing DeLancey's argument leaves no open doors for the TT. Given the truth of Delancey's argument and its compatibility with biology and evolution, it becomes obvious that the TT is not sufficient as a test of intelligence because it completely ignores the importance of autonomy and it marks a major separation between the mind and the body.

Since Turing’s test completely ignores the importance of autonomy, does it mean that it is completely useless? The answer is not straightforward. As a complete test of intelligence, the Turing test can be considered useless. However, its power as an indication of intelligence cannot be ignored. The power of Turing's test comes from the fact that it is based on language and language is a powerful and subtle tool of human intelligence. Since language only emerges from some sort of intelligence, we can be tempted to regard the TT as an intelligence test because what the TT does is basically detecting language.

But we shouldn't so easily let the trap of language fool us into thinking that the TT is a test of intelligence. Biological evolution seems to suggest that robotic capabilities come before linguistic ones. There are many species with autonomous, robotic capabilities with no linguistic capacity, but none that has linguistic capacity without robotic capacity. We don't deny the limited intelligence of a chimpanzee because of its lack of linguistic capabilities although it is obvious that a chimpanzee can't come close to passing the TT. It is hard to imagine that a TT candidate could chat with you coherently about the objects in the world without even having encountered any objects directly (Harnad, 1991).

The TT focuses too narrowly on cognition, disregarding other bodily functions that are essential for intelligence. Presenting the cognitive abilities of intelligence as the representation of an entire organism's intelligence fails to capture intelligence. Autonomy combined with feelings makes possible an organism's direct experience of world. Without direct experience and related feelings, language is nothing more than a string of characters. The TT has no implications for autonomy or feelings so it is hard to be regarded as a test of language let alone a test of intelligence.

Despite the limitations of the TT in measuring intelligence, Turing had the right idea when he first proposed the imitation game. If we want to measure intelligence, it has to depend on something that we can actually measure. Turing proposed language as a measure of intelligence because language is something that we can identify. Although it turned out that language is not powerful enough to identify intelligence, this does not mean that the imitation game is wrong in essence. There are many other aspects of human intelligence. The imitation game can be taken as a functional basis for appraising intelligence and upgraded to provide a more complete test of intelligence using other aspects of human intelligence.

5. A Total Turing Test

When Turing first proposed the imitated game, his main idea was "if it looks like a duck, walks like a duck, quacks like a duck, it's a duck". He was right that if an "artificial" duck acts like a duct in every respect, we have no reason to doubt its authenticity. However the test that he suggested for human intelligence did not actually test if the machine acts like a human in every respect. The imitation game might be assumed to be testing only "quacks like a duct" although I'm not even sure if typing "quack" on a teletype machine with no feelings involved is the same thing as an actual "quack" sound coming from an actual duck as it is of fear or joy. The TT provides no test for "looks like a duck" or "walks like a duct". With AI, we are not so much concerned about the "looks" of an artificial being. So "looks like a duct" is not that important for us. However, we should be concerned about "walks like a duct". In other words, we should be concerned about intelligence as autonomy. An intelligence test has to account for autonomy if it is seriously be considered as a test.

In "Other Bodies, Other Minds," Stevan Harnad proposes a more stringent test called the Total Turing Test (TTT) in place of Turing's original "pen-pal" version of the TT. To pass Harnad's Total Turing Test, "The candidate must be able to do, in the real world of objects and people, *everything* that real people can do, in a way that is indistinguishable to a person from the way real people do it" (Harnad, 1991)

Harnad's TTT is much stronger than the TT. First, it requires that a candidate is an actual physical object such as a robot. Second, passing the TTT entails passing the TT. Besides the TTT requires full robotic capabilities and this makes the successful linguistic performance more probable because the machine now has a direct relationship with the world. Most importantly, the TTT is immune to Searle's Chinese room experiment because the only way to actually perform the Chinese room experiment would be to be the actual machine in question. Moreover, the sensorimotor grounding of the TTT further eliminates "the mindless symbol manipulator" argument.

It seems like Turing's "looks like a duck, walks like a duct, quacks like a duck, it's a duck" argument is fully achieved by the TTT. The only objection to the TTT can be directed from a "Quality of Feelings" angle. As Frank Jackson points out in his article "Epiphenomenal Qualia," no matter how much we learn about the brain, its related states, their functional role, and so on, we don't know anything about the hurtfulness of pains, the itchiness of itches, the smell of a rose and so on unless we experience those feelings ourselves (Jackson, 1984). This means that physicalism leaves out something. As Harnad himself acknowledges, the TTT is incapable (as TT) of distinguishing systems that really have "*private experiences*" that we each know *exactly* what it's like to have from systems that might "*just be behaving exactly as if they had a mind without experiencing anything*".

This argument is in fact no different from assuming that no one else has a mind. There is no evidence for Person A that Person B has a mind unless Person A can experience what Person B experiences at a certain time and conclude that Person B's experiences are identical to his experiences. Since it is impossible to experience what other people can experience, it is impossible to be completely sure that another person has a mind. In this regard, it is unfair to deny experience from a machine because we assume that it cannot experience what we experience. Even if we are sure that it cannot experience what we experience, we should still leave an open door for some type of a machine experience because after all the only way to know how it is to be a machine is to be a machine.

6. How Useful is the TTT?

Isn't the TTT essentially building a human? If we set ourselves the goal of creating some entity that acts like a human in every respect, aren't we essentially saying that our goal is to create a human being out of metal pieces? Isn't the philosophical value of AI to understand the source or nature of intelligence through simple, somewhat intelligent and rational machines? It seems that by requiring a TTT type of test as the absolute intelligence test for our agents, we are getting beyond the initial premise and purpose of AI.

One question to consider is "Why do the Turing Test and the Total Turing Test try to test the human capabilities of a machine?" For example, the Turing Test tries to test the linguistic capabilities of a machine. Linguistics is only one aspect of human behavior and it is exclusive to humans. On the other hand, the TTT tries to test *every aspect* of human behavior. I believe that both tests derive from our constant urge to create a version of ourselves through AI. Since these types of tests determine the direction of AI research, we are always bound to imitating human intelligence.

One of the biggest problems in AI is that we try to measure the success of AI by how much a machine can imitate human behavior. That's why we initially had the TT and that's why it turned out to be insufficient to account for intelligence. Then we turned to TTT that essentially requires building a complete human. TTT can be considered a complete test of intelligence but it does not provide new ways of creating and understanding intelligence.

If we are trying to understand the source of intelligence and rational behavior, we shouldn't be bound by the goal of imitating human intelligence and human behaviors only. We have to accept that intelligent and rational behaviors can be created in ways that do not use human intelligence as their model. AI's success should be measured in terms of the production of rationality and intelligence in machines without feeling constrained to imitate human intelligence.

7. Alternate Rationalities

Imitating human intelligence can be beneficial as a field in AI but it shouldn't be the central motivation of AI. Despite its limitations, the Turing Test was one small step to isolate intelligence from consideration of the body. Now we need to free AI from the unnecessary constraint of imitating human intelligence. Turing's emphasis on outward behavior as a measure of intelligence has to be taken seriously no matter how limited his conception of intelligence was. We have to accept that intelligence can be obtained in endless different forms and that internal operations performed to obtain outward intelligible actions can be different. Every rational and intelligent behavior exercised by a machine should be treated as another step in understanding mind whether in human form or in alternate machine form.

For a long time we wondered about flying. We always wanted to fly and we endlessly tried to imitate flying patterns of birds. Imitating birds helped us understand flying in general. But we could only fly after we discovered the fundamental physical concepts behind flying and created planes that obeyed those rules without worrying too much about one instance of flying, that is birds' flying. The same analogy applies to AI as well. We do not have to imitate or understand every aspect of human intelligence in order to understand or create intelligence. It's time to accept the fact that Deep Junior, the computer that challenged Kasparov, the best human chess player, might possess a type of intelligence. Maybe Deep Blue does not possess the creative, intuitive and humanly type of intelligence that we perform while playing chess but it performs high speed search techniques that no human can perform and finally produces intelligible and rational chess moves quite often better than a human does. Instead of labeling Deep Blue as a mere calculator, it is much more constructive to analyze and try to understand the type of intelligence that it exhibits.

Conclusion

As long as we try to understand intelligence by trying to imitate human intelligence, we will always be bound by the unrealistic expectation of creating human intelligence out of metal pieces. We can either try to imitate every single neuron in our brain and hope these neurons will end up working the same way that our brain does, use the TTT to test if our machines are “human” enough, or we can accept that intelligence can be obtained in alternate forms and try to acknowledge and create those alternate forms in order to better understand intelligence.

In his famous imitation game, Turing separated the bodily features of a human from human intelligence. In doing so, he initiated the idea that intelligence can exist independent of the human body. We should hurry up and follow in the direction that he pointed fifty years ago. It is time to accept that human intelligence is only one form of intelligence and that alternate rationalities can be created in alternate forms from the most familiar human form.

References

Colburn, T. (2000), *Philosophy and Computer Science*, New York, NY: M.E. Sharpe.

Delancey, C. (2002), *Passionate Engines*, New York, NY: Oxford University Press, Inc.

Harnad, S. (1991), 'Other bodies, Other Minds: A Machine Incarnation of an Old Philosophical Problem', *Minds and Machines* 1, pp. 43-54.

Hauser, L. (1993), 'Reaping the Whirlwind: Reply to Harnad's "Other Bodies, Other Minds"', *Minds and Machines* 3, pp. 199-226.

Hodges, A. (1999), *Turing: A Natural Philosopher*, New York, NY: Routledge.

Jackson F. (1984), 'Epiphenomenal Qualia', *Philosophical Quarterly*, 32, pp.127-136.

Penrose, R. (1989), *The Emperor's New Mind*, Oxford UK: Oxford University Press.

Rose, S. (1998), *From Brains to Consciousness*, Princeton NJ: Princeton University Press.

Searle, J.R. (1980), 'Minds, brains and programs', *Behavioral and Brain Sciences* 3, pp. 417- 457.

Seibel, P., "Turing Test, Etc.", http://www.ryerson.ca/~dgrimsha/courses/cps721/turing.htm

Simon, A. (1995), 'Machine As Mind' in *Android Epistemology*, Ford, K., C. Glymour and P.Hayes, eds, American Association for Artificial Intelligence, MIT, Cambridge, MA: The MIT Press.

Turing, A.M. (1950), 'Computing Machinery and Intelligence', *Mind* 59, pp.433-460.