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# Hypothesis-Testing Method in a Community of Psychologists

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## Abstract

Cognitive scientists have become increasingly interested in doing research on the nature of interdisciplinary collaboration. This new direction raises questions about the role that discipline specific practices may have when scientists from different disciplines collaborate. In this paper we explore one such discipline-specific belief: the importance of hypothesis testing in psychology research.

## Introduction

We interviewed scientists about their collaborative processes (Okada, Schunn, Crowley, Oshima, Miwa, Aoki, & Ishida 1995), and a computer scientist who had collaborated with a cognitive psychologist mentioned the following:

“The most important benefit of participating in this interdisciplinary collaboration is that there are scientists who have a different sense of value on science. For example, when working with researchers in the same discipline, we share a common ground and a common language. We can make progress in our project very quickly without wondering about what the co-researcher meant. Now, I think that my co-researcher in this interdisciplinary project and I didn’t share that common ground when we started our project. Therefore, we could not make any progress for about one year. We could not understand what confused us... The difference of disciplines related to the differences in the sense of value on science, methodology that we use, and more concretely speaking, evaluation criteria. Those differences made me feel this interdisciplinary collaboration was very interesting!” [Translated from Japanese]

We have also had similar experiences when working with computer scientists. It seemed that the computer scientists were more concerned with creating phenomena on a computer system, while we, as psychologists, were concerned with understanding phenomena in the real world, through experimental design, hypotheses, and manipulating variables.

These episodes suggest that scientists have beliefs about how science should proceed and be evaluated, and that

these beliefs are discipline-specific. These beliefs influence scientists’ research activities, such as conducting research projects, writing research articles, and advising students’ research projects. In this paper, we will focus on a discipline-specific belief about science that is widely shared in the psychology community. Recently, research interests in interdisciplinary collaboration have been growing in the cognitive science community (Derry & Gernsbacher, in press). An interdisciplinary collaboration, by nature, is an enterprise by collaborators with different beliefs from different backgrounds. Thus, it would be extremely important for us to know what kind of beliefs each discipline brings into the collaboration.

## Hypothesis-Testing as a Prescriptive Method

Scientific psychology has emphasized the importance of justification as a measure for being scientific. The hypothesis-testing style (i.e., entertaining clear hypotheses and testing them based on data) has been adopted as a prescriptive means for justification. When conducting scientific research, many psychologists believe that they must first develop clear hypotheses before testing them against the available data.

This hypothesis-testing style seems to be an offshoot of several dominant movements that emerged in Western psychology in the 1930s: logical positivism and operationism, hypothetico-deductive method, and inferential statistics.

Logical positivism aims to clarify the language of science and investigate the conditions under which empirical propositions are meaningful, then verify the propositions by means of a concrete procedure. This movement in the philosophy of science was introduced to the psychology community in the 1930s by Stevens (1939). Operationism (Bridgeman, 1928), which claims that a scientific concept should be defined by concrete operations to achieve the concept, was integrated into the logical positivism movement. These movements served as a strong theoretical background for the formation of scientific psychology.

The hypothetico-deductive method (H-D method) is a scientific method in which investigators are required to adopt a postulate tentatively and deduce its logical implications, and then check the validity of them by observation. Hull, a founder of neo-behaviorism, adopted it

as a core research method for his studies (Hull, 1943). As neo-behaviorism became dominant in psychology for the next several decades, Hull's emphasis of the H-D method had a strong influence in the psychology community.

With the development and introduction of inferential statistics to psychological research, investigators then had tools to implement logical positivism and the H-D method in their research (Fisher, 1935).

These movements had strong influences on the psychology community, the effects of which are still being felt today. In the rest of this paper, we will address the following questions related to the hypothesis-testing style of research in the community of psychology: How and when was such a belief formed in the psychological community in Japan? What kind of role does this belief about science play in shaping research activities?

The primary data are from the Japanese psychology community. However, we feel that this data reflects the situation of psychology in the Western community as well, since the Japanese psychology community has been strongly influenced by Western psychology, particularly by the USA. Moreover, Kerr (1998) found a similar pattern of researchers' beliefs on the hypothesis-testing style in the psychology community in the USA using a similar questionnaire survey with somewhat a different focus.

### Three Aspects of Research Activities

We will focus on three important aspects of scientific research: 1) Writing journal articles; 2) educating psychology students, and, most importantly; 3) conducting research projects.

#### On Writing Journal Articles

When submitting articles to psychology journals, authors sometimes receive comments that may have been motivated by the belief that research papers without hypotheses are unscientific. Following are examples of comments that our colleagues received from journal reviewers:

"The authors do not make any predictions or provide the foundation for predictions." (Cognitive Science)

"The most serious problem of this paper is that there is no clear hypothesis mentioned. ...You should predict what kind of result you would acquire and describe what the paper would contribute if the result is obtained." (Japanese Journal of Psychology) [Translated from Japanese]

In order to verify whether or not these examples reflect the current situation of the psychology community in Japan, we conducted a questionnaire survey of psychology researchers in 1998. Participants were first and second authors of articles published in the Japanese Journal of Psychology and the Japanese Journal of Educational Psychology over the previous year. Those two journals are bulletins of the two major scientific psychology societies in Japan. A questionnaire was mailed to 137 authors. We received replies from 111 authors—a response rate of

81.2%! The questionnaire included questions about the timeline of developing the hypotheses mentioned in each article and authors' past experiences of hypothesis formation in research activities. Each question will be described in detail in later sections of this paper.

Participants were asked if they had ever received reviewer comments that recommended revising the article to clarify the hypothesis: 25.7% of respondents answered yes. Considering the fact that this question only applies to authors who have previously submitted at least one paper to a journal without including any hypotheses, this rate should be regarded as higher than it appears. This suggests that the Japanese psychology community encourages researchers to write articles with clearly stated hypotheses. On the same issue, Kerr (1998) conducted a similar study, giving a questionnaire to 156 behavioral scientists in the USA. It asked them to estimate what percentage of publishable research articles should state an explicit hypothesis, according to journal editors and reviewers. Respondents thought journal editors and reviewers would say that research articles should state an explicit hypothesis about 80% of the time. Though this research did not focus on respondents' actual experience with reviewers, it does suggest that beliefs about the hypothesis-testing style in journal review processes are widely shared among psychologists, not only in Japan, but also in the USA.

In order to see how such journal review processes affect the style of journal publications, we coded the empirical articles (i.e., articles with data) in the 1997 volume in the Japanese Journal of Psychology (Okada & Shimokido, in press). If any hypotheses, predictions, or expectations were stated in an article, it was coded as an "article with hypothesis." Sometimes, hypotheses were clearly stated in the articles: "The hypothesis of this research is..." or "We have three hypotheses. The first one is..." Sometimes, the expression in an article was more subtle such as, "...was expected" or, "If it is true, this result would happen." We included all of them as "article with hypothesis" because, with this analysis, we wanted to capture how authors were influenced by the hypothesis-testing style of writing. Using this criterion for hypotheses, we divided the empirical articles into four categories. The first category is articles with no hypotheses mentioned. The second category is articles with hypotheses mentioned after the first experiment. The third category is articles with one or more hypotheses mentioned in the introductory section. The fourth category is the articles with two or more hypotheses mentioned in order to distinguish a correct one from wrong ones (i.e., a diagnosis test). The third and fourth categories were regarded as "articles with hypotheses."

The results showed that, in 1997, 58.8% of the empirical research articles in the Japanese Journal of Psychology had some kind of hypotheses written in the introductory section. Note that the other empirical articles, that didn't have any hypotheses, focused mainly on clinical case studies, testing the validity of a questionnaire, or psychophysics, which traditionally are types of articles written without hypotheses. Taking this into account, we can say that the hypothesis-testing style of writing articles

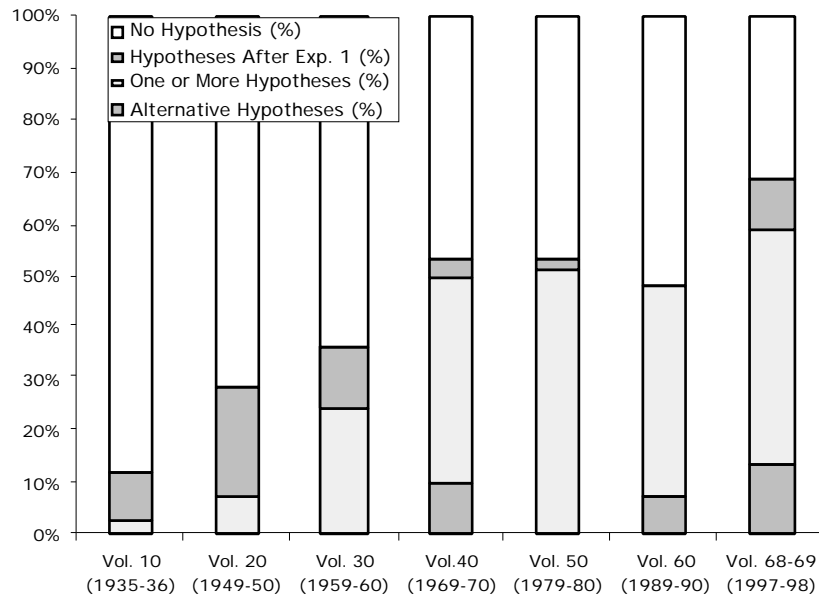


Figure 1: Hypotheses in the Japanese Journal of Psychology

is currently dominant in the Japanese community of psychology.

Do research articles in other disciplines follow the same hypothesis-testing style? We checked the 1996 volumes of Japanese science journals—these were the most recent volumes available in our university library at the time. We looked at the publication lists of the faculty members of each discipline in our university, then chose journals in which they were frequently published. We used the same coding scheme as the one previously mentioned, for the 1997 volume of the Japanese Journal of Psychology.

Table 1. Articles with hypotheses in various disciplines.

journal	Articles with hypotheses
Solid-state physics	0% had hypotheses
Earth Science	0% had hypotheses
Analytical chemistry	0% had hypotheses
Environmental medicine	0% had hypotheses
Neuroscience	0% had hypotheses
Ocean & Sky (Meteorology)	0% had hypotheses
Analytical Chemistry	2.8% had hypotheses
Polymer chemistry	24% had hypotheses

The main result of this analysis is shown in Table 1. As we can see, many research articles in other scientific disciplines do not follow the hypothesis-testing style of writing. Despite the belief about a scientific writing style that our psychology community shares, it seems that many scientists in natural science disciplines do not adhere to the hypothesis-testing style of writing. Are we willing to say that these articles without hypotheses are unscientific?

The next question that occurred to us was whether or not psychology articles have always used the hypothesis-testing style. If movements such as logical positivism, H-

D method, and inferential statistics had influenced research activities in psychology, the hypothesis-testing style of writing should have emerged at some point thereafter and spread throughout the psychology community. In order to answer this question, we conducted a historical analysis of the Japanese Journal of Psychology. It has been published since 1925, is the official journal for the Japanese Psychological Association, and is the oldest and most prestigious psychology journal in Japan. We coded the journal articles using the same coding scheme as previously described.

Figure 1 shows the results of the historical analysis of empirical articles in this journal. We examined every tenth volume of the journal from 1935 to 1998. (The most recent volume was Volume 69 at the time of this analysis.) As shown: 1) There were almost no articles with hypotheses in the introduction published prior to WWII; 2) the number of articles with hypotheses gradually increased after WWII; and, 3) the majority of the articles in the current volumes have hypotheses.

These results suggest that after WWII Japanese psychology researchers formed the standard that scientific articles should have hypotheses clearly stated in the introduction. This standard is quite different from that of the journals in other scientific disciplines. (Currently, we are conducting the similar analysis with American scientific journals so we can verify whether or not this trend is unique to the Japanese psychology community.)

The results of the historical analysis of the Japanese Journal of Psychology agree with the historical evidence regarding the import of the aforementioned movements—logical positivism, hypothetico-deductive method, and inferential statistics—from Western psychology to Japan. Although those movements emerged in Western psychology in 1930s and 1940s, World War II prevented Japanese psychologists from being exposed to

them. When World War II ended, these movements were introduced and gradually adopted into the Japanese psychology community. Theoretical articles on logical positivism and operationism appeared in the 1948 volume (the first volume after WWII) of the Japanese Journal of Psychology. Before WWII, there was very little research in behaviorism in Japan. After WWII, neo-behaviorism was introduced. For example, symposia on behaviorism were held at the 13th annual conference of the Japanese Psychological Association in 1949. Inferential statistics were introduced to Japan right after WWII. In the Japanese Journal of Psychology, the first theoretical article on inferential statistics appeared in the 1948 volume of the Japanese Journal of Psychology and the percentage of articles with inferential statistics increased dramatically during the 1950s (Omi, 1997).

From this evidence, we believe that it would be a fairly valid inference that a new belief about the hypothesis-testing style of writing articles among Japanese psychology researchers was influenced by logical positivism, hypothetico-deductive method, and/or inferential statistics.

### On Teaching How to do Research

During four years of teaching in a psychology department in Japan, the first author found that many psychology majors were taught that they must form clear hypotheses before collecting data. An undergraduate student in a research methods course complained to him, "Although I want to study this topic, I cannot come up with a clear hypothesis. So, I cannot study this topic." A graduate student writing a master thesis came to his office one day and confessed, "Though I conducted three experiments for my master thesis, I could only come up with a clear hypothesis in the last experiment. So, I may not have the ability to conduct scientific research."

In the process of learning about psychology, many students seem to acquire the idea that they have to form a clear hypothesis in order to conduct a psychological research study. In the questionnaire survey mentioned in the last section, we asked the following questions:

1. When you were a student, had you ever received advice from someone telling you that you should start a research project by developing clear hypotheses? *77.4% of respondents answered yes.*
2. When writing papers, had you ever received advice telling you that you should write clear hypotheses in the paper? *65.1% of respondents answered yes.*
3. Have you ever read a textbook on research methodology of psychology suggesting that you should start with clear hypotheses when conducting research? *70.8% of respondents answered yes.*
4. Have you ever given advice to someone telling him or her that when conducting research they should develop clear hypotheses before collecting data? *69.8% of respondents answered yes.*

Overall, the percentage of the respondents who answered yes to at least one of the above questions was

90.1%. Thus, the hypothesis-testing style seems to be the dominant practice in Japanese psychology.

The results of this survey are not surprising because many research methodology textbooks in psychology also mention that psychological research should proceed by finding questions and entertaining clear hypotheses first, then by collecting data. This is an excerpt from popular Japanese textbooks about research method in psychology.

*How to conduct research and write a paper*, Sirasa (1987): "The research process is the process of testing hypotheses... Thus, entertaining hypotheses is a very important first step to start research. If you think that you can discover something when conducting a survey or experiment with vague ideas, you will never succeed in your research."

The same trend was found in textbooks in the USA (Kerr, 1998). It seems that both in Japan and in the USA, psychology undergraduate and graduate students have been taught to use the hypothesis-testing style of research and to write articles following that style.

### On Conducting Research Projects

Our questionnaire survey was individualized for each respondent. We identified hypotheses in an article they had published and asked the authors specific questions about the hypotheses. If no hypothesis had been stated in their article, the same question was asked without identifying any specific hypothesis. The question was regarding whether they had developed the hypothesis written in their paper before they had collected the data. Respondents had to choose one of the following answers: a) The same hypothesis was entertained throughout; b) a different hypothesis was entertained; c) a vague hypothesis was entertained; d) no hypothesis was entertained; or (e) others.

In the case of articles with hypotheses, 70.6 % of the respondents said that the same hypotheses had been entertained throughout the study. However, 23.5% of the respondents admitted that they had different hypotheses, vague hypotheses, or no hypotheses at all before collecting data. Thus, we found that even if there are hypotheses clearly written in journal articles, it does not necessarily mean that the authors used the hypothesis-testing style when conducting their research. That is, in some cases hypotheses may have been developed between data collection and the writing of the paper. When interpreting the data, we have to consider that this survey was addressed to authors who have successfully published articles in mainstream psychology journals in Japan. It is highly possible to imagine that many psychologists who conducted research without hypotheses either could not publish their work in those mainstream journals or did not have the courage to submit them.

These results tell us somewhat contradictory stories about psychologists' research activities. While researchers in psychology conduct research in diverse ways (i.e., sometimes starting with a hypothesis and sometimes without), when they write journal articles they often imply that they had conducted the hypothesis-testing style of

research. When researchers teach others how to conduct research, they strongly emphasize employing the hypothesis-testing style. Does this mean that those psychologists who could not come up with any hypothesis before collecting data are not practicing the “correct” method of scientific research? Is the hypothesis-testing style really the best and the most scientific method of conducting research?

### **Potential Problems with the Hypothesis-Testing Style of Research**

Many philosophers of science have pointed out that scientists are not necessarily using the hypothesis-testing style of research when conducting scientific research (e.g., Hanson, 1958). Scientific discovery processes have two main phases: discovery of an explanation and justification for it. The hypothesis-testing style of research is strongly related to the justification side of scientific discovery processes, but not as much to the discovery side. Therefore, it does not completely reflect the actual process of scientific discovery. For example, Hanson (1958) stated in his famous book, *Patterns of discovery*:

“Physicists do not start from hypotheses: They start from data. ...H-D accounts begin with the hypothesis as given. ...The H-D account describes what happens after the physicist has caught his hypothesis; but it might be argued that the ingenuity, tenacity, imagination and conceptual boldness which has marked physics since Galileo shows itself more clearly in hypothesis-catching than in the deductive elaboration of caught hypotheses.”

Like Hanson, it seems that the majority of philosophers of science abandoned the concept that the hypothesis-testing style of research was the ideal scientific method a long time ago. However, as we have described, many psychology researchers still believe that this method is the best (and sometimes the only) scientific method that psychology should follow.

### **Various Styles of Research in Science**

Some scientists have pointed out that they are actually conducting research and producing prominent findings using other research styles. For example, Herbert A. Simon (1991), one of the founders of the fields of cognitive science, artificial intelligence, and cognitive psychology, has written about his research style as follows:

“When I examine my other experimental research, I find to my embarrassment that this fundamental condition for sound experimentation is seldom met. What have I been up to? What can I possibly have learned from ill-designed experiments? The answer (it surprised me) is that you can test theoretical models without contrasting an experimental with a control condition. And apart from testing models, you can often make surprising observations that give you ideas for new or improved models...”

“Perhaps it is not our methodology that needs revising so much as the standard textbooks on methodology, which perversely warn us against running an experiment until precise hypotheses have been formulated and experimental and control conditions defined. Perhaps we need to add to the textbooks a chapter, or several chapters, describing how basic scientific discoveries can be made by observing the world intently, in the laboratory or outside it, with controls or without them, heavy with hypotheses or innocent of them.” (pp. 383-385.)

Simon (in press) describes a case study of Faraday and further argues that curiosity and careful observation, which often lead to surprising results, are centrally important values to the scientific enterprise.

It seems that, at least in some scientific disciplines, scientists conduct research without using the hypothesis-testing style. They form hypotheses after observing phenomena.

### **The Cognitive Psychology of Scientific Thinking**

This point is supported by further evidence from studies in cognitive psychology. In the field of cognitive psychology, there have been substantial numbers of studies focused on scientific discovery processes (e.g., Klahr & Dunbar, 1988; Okada & Simon, 1997; Schunn, 1995). These studies suggest that: 1) Subjects frequently design experiments without hypotheses; 2) the frequency with which subjects design experiments without hypotheses is higher at the beginning of research; 3) there are individual differences in whether people tend to design experiments without hypotheses (experimenters who start experiments without hypotheses versus theorists who start experiments with hypotheses). These results fit with our findings from the questionnaire survey. Together, they converge to tell us that there are various research methods and styles in science.

### **Advantages and Disadvantages of Scientific Styles**

Hypothesis-testing styles of research, which are based on the H-D method and strong inference (Platt, 1964: i.e., develop alternative hypotheses and devise a crucial experiment that excludes one or more of the hypotheses, then carry out the experiment so as to get a clean result), are probably useful when the research field has been well-developed or the research project has progressed up to the level that the researchers do not need to create any new paradigm or theory. Although the percentage of articles which used strong inference in psychology journals is not high (see Figure 1), Platt (1964) claimed that this scientific method is the most productive way to conduct scientific research.

However, we feel that his claim is probably too strong to generalize. In certain situations, the H-D method (especially strong inference) might not work well. For example, when the research field is not well formed yet, or the research project is at the starting stage, the hypothesis-testing style of research might force researchers to form a hypothesis prematurely. Toyoda (1998) pointed out that

even a study with a precise statistical analysis to distinguish rival hypotheses might only be able to distinguish the rival hypotheses that are located very close to each other in a highly complicated hypothesis space. Therefore, when there is no valid reason to form hypotheses with the currently available data and theory, there is a possibility that the researchers will focus on hypotheses that are far apart from the correct hypothesis. In such a case, they might be stuck with irrelevant questions or irrelevant hypotheses that might not lead to any major discovery.

## Conclusion

In the historical and social context of Japanese psychology, many psychology researchers in Japan acquired the belief that the hypothesis-testing style was the best, and sometimes the only, scientific way. Such a belief creates a cognitive constraint (Miyake & Hatano, 1991; Siegler & Crowley, 1994) on the way that psychology researchers participate in research activities such as conducting research, writing research articles, and teaching research methods. Such a belief, on one hand, has a positive effect in enhancing effective research activities—many research articles have been published using this hypothesis-testing style. However, on the other hand, there could be situations in which such a belief has negative effects on research activities. As we have shown above, it was suggested that some articles without hypotheses have been rejected by journal reviewers as non-scientific even though such articles might have made a great contribution to the community of psychology, had they been published. It was also suggested that such a belief shaped types of research procedures that might have distorted researchers' views on scientific discovery. As for the educational aspect, it was suggested that some of the psychology students felt discouraged to explore new research directions because they received advice emphasizing the hypothesis-testing style of research.

We believe that the information from these analyses about researchers' beliefs in psychology would be useful when we try to understand cognitive processes among psychologists and other scientists in an interdisciplinary collaboration.

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