An Interbehavioral Account of the Participation of Women in Science

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Abstract

The overarching goal of scientific exploration of phenomena has been thoroughly examined by relatively few behavior analysts. J. R. Kantor (1953) discussed this goal with respect not only to the general practice of science but to the scientist as well. Discussions concerning the participation of a scientist within their scientific enterprise have recently come of interest with the increasing attention received by women’s engagement in various fields (Shen, 2008; Selinas & Bagni, 2017). With respect to behavior analysis, discussions of this sort have been approached 12 times (Stedham et al, 2018). This thesis developed a construct influenced by J.R. Kantor’s approach that allowed for the identification of novel forms of participation of scientists within their enterprise that provided us with direction concerning where changes need to occur to see movement with respect to this participation. The purpose of this thesis was (1) to update and extend analyses on publications in three behavior analytic journals, (2) to provide a coherent philosophical system that allows for an analysis of participation, (3) to utilize this philosophical system to identify measures of the participation of women in science that have been analyzed by fields outside of behavior analysis, (4) to explore the relation between various products and activities that may lead to more pragmatic solutions to increasing the participation of women in science.
This thesis is dedicated to my effervescently rambunctious daughter, my extremely intelligent and resilient mother, and to all the women scientists who have struggled and will have to struggle to find their place. I see you. I am you.
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Over the past several decades gender related issues have come to the forefront of many cultural and political discussions. The general concern for gender equality as it pertains to the participation of women in the fields of science, technology, engineering, and mathematics (STEM) has received increasing attention (Shen, 2008; Miller & Wai, 2015; Selinas & Bagni, 2017). This increased attention has included discussions of gender related issues that are approached by various scientific enterprises, including but not limited to anthropology, communications, sociology, social psychology, women’s studies, and behavior analysis. With respect to behavior analysis, discussions of this sort have been approached 12 times (Stedham et al., 2018). Figure 1 depicts the cumulative number of articles published in behavior analytic journals that have focused on the participation of women in behavior analysis. Although there were several articles published in the early 1980’s and 1990’s the number of articles published on the topic increase steadily from 1997 to 2001 and decrease between 2002 and 2015 when there was only one article published. Recently, however the publications on the topic from 2016-2018 have increased at the same rate that was seen previously. This indicates that there may be a renewed interest in analyzing the participation of women in the field.

Concerning the participation of women in behavior analysis, previous research has focused primarily on three lines including, trends in publication (Poling et al, 1983; Iwata, 1984; Myers, 1993; Neef, 1993; McSweeney & Swindell, 1998; McSweeney et al, 2000; McSweeney et al, 2002; Simon et al, 2007; Nosik & Grow, 2016; Lee et al 2018), participation in the editorial processes for behavior analytic journals (Myers, 1993; Neef, 1993; McSweeney et al, 2000; Odum, 2000; McSweeney et al, 2002; Lee et al, 2018; Nosik, 2018), and membership and participation at the annual Association for Behavior
Analysis (Poling et al., 1983; Myers, 1993; Simon, Morris & Smith, 2007; Nosik, 2018). With respect to publication trends, most findings have indicated that women appear in behavior analytic publications as authors, both senior and junior combined, less frequently than men. Others have argued that the lower level of participation in the form of publication may simply be a function of lower submission ratios; the fewer articles submitted by women equates to fewer publications by them (Myers, 1993). Odum (2000), however, cautions that this may be an artifact of the relative number of women who are engaged in the various domains of behavior analysis. In keeping with Odum’s cautioned, Nosik et al. (2018) found that in the Journal of Applied Behavior Analysis in 2005 approximately 50% of the publications included authorship by women. They suggested that this finding may reflect the growth in representation of women in the applied domain of behavior science, with a correlated 88% of newly credentialed Board-Certified Behavior Analysts in 2016 being women. However, it has been argued that publications by women in journals specific to basic and conceptual domains of the science remain relatively low (Simon, Morris & Smith, 2007; Nosik et al., 2018).

**Publication Trend Analysis**

With respect to the analysis of publications within behavior analysis, there have been a number of accounts that have explored the distribution of gender across first authorship; however, aspects of the gender coding systems that have been implemented, as well as the technologies that have been available, have varied significantly. For example, Poling et al. (1983) do not indicate how gender was identified and McSweeney
and Swindell (1998) coded any unidentifiable initials as male. By contrast, more recent analyses (e.g. Lee et al, 2018; Nosik et al, 2018) utilized resources (e.g. online search engines and social media), that were not available previously, that likely allowed for more accurate data collection.

As such, rather than extending previous findings (e.g. Simon et al., 2007), our first examination provides an extensive trend analysis of authorship of publications in three flagship behavior analytic journals, Perspectives on Behavior Science (PBS), the Journal of the Experimental Analysis of Behavior (JEAB), the Journal of Applied Behavior Analysis (JABA), from their first release to 2018. These journals were selected to represent all three domains of behavior analysis—conceptual (PBS), basic (JEAB), and applied (JABA).

**Publication Trend Method**

The gender coding system that was utilized is comparable to that implemented by Nosik et al. (2018) and Lee et al. (2018). First authors were coded as female if their first name was conventionally feminine (e.g. Maria, Linda) and as men if their first name was conventionally masculine (e.g. Steve, Edward). For unconventional first names (e.g. Sigrid) or unisex names (e.g. Francis, Sydney) or when only initials were utilized, resources such as online search engines or social media were used to locate either the full name or a profile (e.g. Google search, university profiles, LinkedIn, ResearchGate, etc.) that might include a picture or other gender specifying information. Any author, whose gender was unspecifiable following the utilization of these resources, was excluded from these data.
Each issue of PBS, JEAB, and JABA from the onset of each journal to 2018 was examined. These journals were selected based on their emphasis of subject matter (e.g., behavior) and consideration of perceived audience. All articles were coded for the gender of the first author. Point-by-point IOA was conducted by a second observer who coded 33.3% of years in which articles were published within each journal with the IOA for all three hitting at or above 80% agreement. From these data collected in PBS, JEAB, and JABA from 1985-2018 we identified (1) the gender of the first author of articles published, (2) the proportion of male and female first authorship, and (3) the cumulative number of publications by males and females.

**Publication Trend Results**

The y-axes on the even numbered graphs represent the proportion of male and female first-authorship, blue being male and red being female. We utilized proportion as some years had more publications than others per year within and across journals. Further, historically in trend analyses completed in behavior analytic research concerning participation in the form of publication, proportion has been used. The y-axes on the odd numbered graphs represent cumulative number of articles published in each journal. The x-axes on both the proportion graphs and the cumulative records represent time in the unit of years from the inauguration of each journal until 2018.

Figure 2 represents the proportion of male and female first authorship within PBS from 1978 to 2018 (40 years) and Figure 3 represents the cumulative number of male and female first authorship within the same time frame. Upon an initial analysis, it appears as though the trend is indicating a slight increase in female participation overtime with a
slope of $y = 0.0015x + 0.8701$ and an $R^2 = 0.0374$. However, this may be skewed by the participation in 2015 alone when a special issue on women in behavior analysis was released. The following year, the representation returned to the predicted trend. Upon the removal of this, the trend line appears to flatten with a slope of $y = 0.0004x + 0.8565$ and $R^2 = 0.0048$. Of the 1,107 articles that have been published in PBS from 1978-2018, 929 have been published by males and 178 have been published by females; females have published 16% of the total articles in PBS.

Figure 4 represents the proportion of male and female first authorship within JEAB from 1958-2018 (60 years) and Figure 5 represents the cumulative number of male and female first authorship within the same time frame. We found an increasing proportion of female participation over time with a slope of $y = 0.0039x + 8.5933$ and an $R^2 = 0.5757$. Of the 4,267 articles that have been published, 3,816 have been published by males and 451 have been published by females; females have published 10% of the total articles in JEAB.

Figure 6 represents the proportion of male and female first authorship within JABA from 1968 to 2018 (50 years) and Figure 7 represents the cumulative number of male and female first authorship within the same time period. Just as Nosik et al. (2018), we found that there is an increasing proportion of female participation over time with a slope of $y = 0.0092x + 0.0635$ and an $R^2 = 0.8197$. However as opposed to Nosik et al. (2018), we detected the closest approximation to equal participation as occurring in 2014 where first author publication occurred at a proportion of 0.51 male to 0.49 female. In 2013 there was a cross-over where females participate for the first time at a rate higher
than that of the males dropping down to near equal participation in 2014 and from 2015 onward females participate at a higher rate. Of the 3,483 articles published in JABA from 1968-2018, 2,336 articles were published with males as first author and 1,147 articles were published with females as first author; females have published 33% of the total articles in JABA.

Figure 8 represents the total proportion of male and female first authorship across all three flagship journals from 1956-2018 and figure 9 represents the cumulative number of male and female first authorship across the same data set and within the same time period. There is an increasing proportion of female participation overtime with a slope of $y = 0.0062x + 1.0127$ and an $R^2 = 0.883$. Of the 8,857 total articles published across PBS, JEAB and JABA, 7,081 were published by men and 1,776 were published by women; women have published 20% of the total number of articles in these journals. In summary, all three of the journals examined here (with the exception of PBS, if the outlier is removed) are trending toward equal participation across gender, with a cross-over occurring in JABA in 2013 (see table 1 for a summary of results). As such, although females have published fewer articles than males since the onset of these journals, they are contributing at a rate that is trending toward more equal participation in the form of first authorship publications.

What constitutes Scientific Participation?

Poling et al. (1983) argued that “publication data alone may provide an inaccurate reflection of the extent of women's activities in behavior analysis…they may contribute to the field in other ways…” The participation of a scientist within their scientific
enterprise is inherently complex and may, as such, prove to be difficult to capture. This is to say, there are multiple forms of participation, not all of which are readily detected or measured. Further, not all these forms impact the science directly—some just build upon the repertoire of the scientist. If the analysis of the scientific participation of women in behavior analysis is to continue, further investigations ought to identify novel forms of scientific participation related to those which may initially appear less accessible for analysis.

The analyses discussed previously examined only a small portion of these potential forms of participation and provide only problems to be solved, but no data-based decisions concerning where or how these problems can be approached. For example, Simon et al (2007) found that women present less frequently as first authors in symposiums at ABAI, but suggestions as to how this might be changed are not provided. As such, analyses such as these may benefit from a discussion concerning the intricacies of what participation in a science is. These analyses might allow us to move away from only identifying problems to providing direction as to where and how can we implement changes to create movement away from them.

The purpose of this thesis was (1) to update and extend analyses on publications in three behavior analytic journals, (2) to provide a coherent philosophical system that allows for an analysis of participation, (3) to utilize this philosophical system to identify measures of the participation of women in science that have been analyzed by fields outside of behavior analysis, (4) to explore the relation between various products and activities that may lead to more pragmatic solutions to increasing the participation of
women in science. The following sections first discuss scientific participation from the standpoint of J. R. Kantor. Following this, a reconsideration of Kantor’s account is provided. Then it is argued, through several demonstrations, that the new account may allow us to interact with participation of women in behavior analysis in more pragmatic ways.

**An Interbehavioral Account of Participation**

**Scientific Work**

Kantor’s *Logic of Modern Science* provided a detailed analysis of scientific enterprises. He identified six features relevant to any such analysis. These features included (1) the worker, (2) the work, (3) the things worked with, (4) the tools and instruments, (5) the culture, and (6) the products. Kantor (1953) stated, “the basic work of science consists of so interbehaving with things and events as to increase our knowledge of them”. In other words, scientific work—participation—involves the scientist, with their unique history, interacting as an organism with the subject matter of their science in such a way that develops that science further. As such, the features critical to our analysis of participation of a scientist within a science have been identified by this thesis as being the worker/scientist, the work/interaction as an organism with the subject matter, and the products/that develops the science further.

Kantor (1953) identified interbehaviors that involve the scientist working in immediate contact with the subject matter of their science. This interbehavior can take the form of direct observation, instrumental observation, transforming contacts, and remote observation. Within the field of behavior analysis some examples include the following:
interacting with data gathered from direct observation, manipulating contingencies in a contrived setting such as the operant chamber through instrumental observation and remote observation, or a practitioner interacting with a client and manipulating the contingencies surrounding a response through transforming contacts. Kantor (1953) also discussed the products that result from immediate contacts with the subject matter of the science. These included the development of methods and techniques (e.g. the development of extinction as a procedure), apparatuses (e.g. the operant chamber), formalized records (e.g. the Journal of Applied Behavior Analysis, or Skinner’s 1953 book *Science and Human Behavior*), and the development of scientific laws (i.e. the principle of reinforcement).

**A Modification to the Conceptualization of Scientific Work**

Kantor’s conceptualization allowed us to identify various forms of participation by clearly defining them as direct interaction with the subject matter and the products that may result from them; he identified these as scientific work. However, if we are to capture the complexity of a scientist’s interaction within their enterprise it is necessary to expand our understanding of scientific participation beyond the direct interactions discussed above. As such, various forms of participation have been synthesized into two pragmatic categories—scientific activities and scientific products—and expanded upon Kantor’s approach by including interactions with the subject matter that occur by indirect means.

*Scientific activity* is defined as (1) the *direct* interaction of a scientist with the subject matter through *application of* scientific products (e.g. instruments, procedures, laws, etc.)
or (2) the *indirect* interaction of a scientist with the subject matter through *contact with* scientific products. Direct scientific activity includes any instance in which a scientist is engaging immediately with the subject matter of their science through laboratory experimentation or observation, or directly in the field. The application of a scientific product could involve the utilization of constructs or technologies developed previously in order to manipulate or influence the subject matter of the science (e.g. to increase a particular response under specific conditions one might apply the procedure of reinforcement). With respect to indirect scientific activities, *contact with* a scientific product specifies that the scientist’s interaction with them does not alter or influence the subject matter in any immediate way. An example of an indirect scientific activity is as follows, in a symposium conducted at the Association of Behavior Analysis International conference in 2017 on the culture of science, Fryling described the way in which the editorial process selects research that is disseminated to others within the enterprise. As such, he argued that individual editors or reviewers may come to shape various aspects of the science through the editorial process. When editing, an individual is interacting with a product of scientific activities, they are not directly engaging with or influencing the subject matter of their science. However, what passes through the editing process may indirectly influence a scientist’s repertoire whereby their direct activity may later be influenced through the application of this product.

Therefore, what the above distinction of scientific participation adds to this discussion are activities that may not involve the direct interaction with events or lead to the immediate construction of scientific products. These more indirect activities would consider various undertakings related to a scientific enterprise (i.e. contribution to
editorial processes, conference attendance, memberships in various enterprise specific associations, etc.), the development of an individual scientist’s scientific repertoire (i.e. pages read, classes attended, philosophical systems contacted, etc.), or that lead to opportunities that at some point may allow the scientist to engage in more direct scientific work (i.e. stipend or practicum positions engaged in, networking opportunities provided, etc.). These are irrefutably related to the scientific enterprise and, as shown, in some cases may even direct the course of the science.

In this reconsideration of Kantor’s (1953) description of scientific work scientific products are defined as refined constructs resulting from the accumulation of scientific activities of an individual scientist or any number of scientists. Refined constructs are those which are considered by some group or governing body as meeting specific review or criteria guidelines (e.g. they have passed through peer review processes; committees reviewing theses, dissertations, or tenure; certification boards, etc.). As opposed to outcomes, scientific products have gone through some review process that identifies them as being adequately related to the enterprise as a whole; just because someone says they are engaging as a scientist within their enterprise, does not alone qualify the outcome of that interaction as a product of that science. As such, any product, whether it’s an apparatus, law, book or journal, all may be considered refined constructs and as such, Kantor’s original conceptualization of scientific products resulting from direct interactions is still captured. However, clarifying that these products are accumulated through the activities of an individual scientist or several scientists allowed us to identify products that may not have initially been considered. Let’s take for example, tenure or degree reception. For both, many indirect and direct activities such as reading, attending
or teaching classes, performing research, publishing, meeting and defending in front of a committee are required to obtain the final product—full tenure or a master’s or doctorate degree.

**Categorization of Historical Accounts of Women’s Participation in Behavior Analysis**

By sorting the previous accounts of participation of women in behavior analysis with respect to the insight provided the account of scientific work presented here, we may more readily determine where further examination may be warranted. If scientific products are dependent upon the participation in scientific activities, identifying where participation may be lacking with respect to them, might aide in an understanding concerning where changes need to occur to see growth and movement with respect to those scientific products. In applying the reconsidered account of scientific work to the literature that has examined women’s participation in behavior analysis there were two indirect activities, zero direct activities, and ten products identified (see Table 2).

**Novelty of Measures**

The reconsidered approach to Kantor’s scientific work provided us with the opportunity to identify novel forms of participation—direct/indirect scientific activities and scientific products—of a scientist within their enterprise. This allowed for the consideration of direction concerning as to where changes need to occur to see movement with respect to this participation. However, this topic has been approached with respect to fields outside of behavior analysis and although certain measures may appear to be novel, in that they have not been approached by behavior analysts, perhaps they have already
been identified in interpretations provided outside of behavior analysis. The purpose of this examination was to (1) utilize the reconsideration of scientific work to categorize accounts of the participation of women in fields outside of behavior analysis and (2) to identify whether these fields have approached the topic in ways that are novel to our field.

**Novelty of Measures Method**

Four fields outside of behavior analysis were selected for the categorization of measures of the participation of women. These fields included: biology, physics, clinical psychology, and cognitive neuroscience. These were selected to broadly represent an array of STEM fields as categorized by the National Science Foundation’s classification system: computer and mathematical science, engineering, life science, physical science, and social science (National Science Board, 2014; Miller & Wai, 2015). Biology was selected to represent life science and physics for physical science. Cognitive neuroscience and clinical psychology were selected to represent two alternative fields of psychology. A sampling of 12 articles discussing the participation of women within each individual field (N=48) was selected based on the emphasis of subject matter and consideration of perceived audience. The articles were required to come from journals that had an impact factor at or above 1. The search criteria included the field of interest (i.e. physics), “participation”, “women”, “gender”, “sex” etc. The measures of participation in each article were documented and categorized based upon their form (i.e. indirect/direct activity or product).
Novelty of Measures Results

Including the 12 articles from behavior analysis there is an N=60 for Table 3. Although only 48 articles were included in addition to the 12 from behavior analysis, many of the articles analyze more than one measure per article. As such, there are far more than 48 measures identified within these data. With respect to clinical psychology 12 indirect activities, zero direct activities and 42 scientific products were measured. Those analyzing participation in cognitive neuroscience measured 43 indirect activities, 3 direct activities and 42 scientific products. In regard to biology there were 14 indirect activities, 1 direct activity and 12 scientific products measured. Those examining participation in physics measured 50 indirect activities, 2 direct activities and 36 scientific products. In total, concerning participation in all five fields there were 134 indirect activities, 6 direct activities and 143 scientific products measured. (See Table 3)

Concerning measures of women’s participation that were shared with behavior analysis, regarding clinical psychology there were 2 indirect activities, 0 direct activities and 6 scientific products shared. With respect to cognitive neuroscience there were 2 indirect activities, 0 direct activities, and 6 scientific products shared. The articles that analyzed participation in biology shared 1 indirect activity 0 direct activities and 1 scientific product. Concerning participation in physics there were 2 indirect activities, 0 direct activities, and 8 scientific products shared. In total, across these four fields there were 7 indirect activities, 0 direct activities and 22 scientific products shared with behavior analysis. (See Table 4).
The measures of participation that were novel to those identified within behavior analysis, regarding clinical psychology 42 novel indirect activities, 3 novel direct activities and 36 novel scientific products were measured. With respect to cognitive neuroscience 23 novel indirect activities, 0 novel direct activities and 36 novel products were measured. Concerning biology 13 novel indirect activities, 1 novel direct activity, and 11 novel scientific products were measured. Those analyzing physics measured 48 novel indirect activities, 2 novel direct activities and 28 novel scientific products. Although some of the novel measures were shared between the articles analyzing participation in these scientific fields, we are only accounting for those which were novel to behavior analysis. As such, there was a total of 126 novel indirect activities, 6 novel direct activities and 111 novel scientific products from these four fields. (See Table 5).

An additional analysis was run to identify the gender of the first author of each article examining the participation of women from all five fields. There was an N=57 because 3 articles were editorials without any authors identified. With respect to behavior analysis there were 4 males and 8 females; females were first authors for 66.67% of the articles. Concerning clinical psychology there were 3 males and 8 females; females were first authors for 72.73% of the articles. For the articles measuring participation in cognitive neuroscience there were 4 males and 6 females; females accounted for 60% of the total articles. In regards to biology, there were 2 males and 10 females; females were first authors for 83.33% of the articles. For the articles measuring participation in physics there were 3 males and 9 females; females were first authors for 71.93% of the articles. In total there were 16 male first authors and 41 female first authors; females accounted for 71.93% of the total first authors for the articles examined here. As such, with respect to
the articles on women’s participation analyzed here, women wrote more articles on the topic than men (See Table 6).

Overall, every measure of participation that had been analyzed within behavior analysis was shared with some measure analyzed with respect to one of the four fields examined here. Therefore, behavior analysis provided no novel measures of the participation of women. As is discussed later, the most interesting measures provided from the articles analyzing participation in the other fields are those that fall under the categories of indirect and direct activities. These tend to be those which may be described as too difficult to capture. However, these indirect and direct activities are what lead to the creation of scientific products. Therefore, it is argued that if a gender based comparison of scientific products finds that there are fewer women participating than men, perhaps identifying indirect and direct activities that are related to the development of these provides direction as to where the participation of women is falling off and furthermore where intervention may be implemented.

An Exploration of Novel Scientific Products

As stated previously, the purpose of this thesis was (1) to update and extend analyses on publications in three behavior analytic journals, (2) to provide a coherent philosophical system that allows for an analysis of participation, (3) to utilize this philosophical system to identify measures of the participation of women in science that have been analyzed by fields outside of behavior analysis, (4) to explore the relation between various products and activities that may lead to more pragmatic solutions to
increasing the participation of women in science. This section will discuss the fourth portion of the purpose.

Future examinations may explore the direct relation between various activities and products. The potential of these is considered further in the discussion section below. The scope of this thesis allowed for further examination of two additional products. First we examined the credentials (MA, PhD, and Other, e.g. BS or MD) of the first authors of the journals analyzed in the Publication Trend Analysis section (PBS, JEAB, and JABA) from 2014-2018. Following this we examined the distribution of gender with respect to the faculty from the top 3 schools across the five fields analyzed in the Novelty of Measures section (clinical psychology, behavior analysis, cognitive psychology, biology and physics).

**Credentials of First Authors in Flagship Behavior Analytic Journals**

**Credentials of First Authors Method.** An internet search using google chrome was completed. The first relevant document that described the author’s credentials at the time of publication was used. Relevant documents included curriculum vita, Linked-in profile, ResearchGate, professional organization awards, professional conference introductions/bios, academic institutions web pages/bios/job descriptions, National provider identifier (NPI) records, and theses/dissertations. Once a relevant document was identified the corresponding degree was used to score the person in a spread sheet by gender and credential type. Credentials were categorized as male/female Master’s, male/female PhD, and male/female Other. Other represented practitioners from other fields who had not received an MA or PhD, these include but were not limited to
bachelor level students (BA or BS) or individuals with their medical degree (MD) but no PhD. If an author’s credentials were not identifiable they were excluded from these data; all first authors were identifiable.

**Credentials of first authors results.** The trend analysis of male and female publications across behavior analytic journals by credentials demonstrates several patterns. PBS shows relatively few Master’s level practitioners with a decrease overall for males and near zero publications for females. JEAB displays an equal proportion of male and female Master’s level publications in 2014 and 2015 with a decrease in male publications from 2016-2018 and an increase in female publications in the same time frame. JABA has more movement overall regarding the proportion of male and female Master’s level publications however, females tend to publish at a much higher proportion overall than males and there appears to be an overall increase in female publications from 2014-2018. (See Table 7).

With respect to PhD level first author publications within PBS, there appears to be no predictable trend for males or females, however, overall males tend to publish at a higher proportion than females. JEAB shows similar unpredictability in its trend of male and female first authors with PhD credentials, however, as with PBS overall males publish at a higher proportion than females. JABA shows near equal proportions of first author publications by males and females with PhD credentials, with males publishing at a higher proportion than females only in 2017. (See Table 8).

Concerning publications from authors that met neither MA/MS nor PhD credentials, both PBS and JABA have near zero publications from both males and
females. Within JEAB, for the years in which there were publications from authors who met neither MA/MS nor PhD credentials, males and females appear to publish at a near equal proportion with an exception in 2016 where there were no publications by males. (See Table 9).

**Faculty from Top Three Graduate Programs in Five Fields**

**Faculty from top three graduate programs in five fields method.** In order to determine the top three graduate programs for Clinical Psychology, Cognitive Neuroscience, Biology and Physics the U.S. News & World Report graduate program ranking system was utilized. According to their website, the data U.S. News gathers on colleges, as well as the rankings, “serve as an objective guide by which students and their parents can compare the academic quality of schools”. The rank that each school is given, is based on the same set of quality measures across all institutions within the same categories (i.e. undergraduate/graduate programs). This ranking system was accessed online at https://www.usnews.com/best-graduate-schools. The name of each field was set as the categorization criteria (e.g. “physics”) whereby only the top graduate programs from within the specified field were represented. Once the top three programs for a field were identified, each program’s most current (as of the Spring 2019 semester) faculty website was accessed. The genders of the faculty were then identified as either male or female by utilizing the same gender coding systems as that used in the trend analysis method. Because Behavior Analysis graduate programs were not represented on the U.S. News and World Report ranking list, three schools were selected based on the following four criteria, (1) they provide a Behavior Analysis Certification Board (BACB) course
sequence, (2) they are an ABAI accredited program, (3) they have been a program for 20 or more years, and (4) they offer both a Master’s and PhD track. Although there are a number of schools that meet these criteria, only three were selected.

**Faculty from top three graduate programs in five scientific fields results.** The top three Clinical Psychology graduate programs included, the University of California—LA, the University of California—Berkeley, and the University of North Carolina—Chapel Hill. There was a cumulative total of 52 faculty members, 25 were male and 27 were female. Females accounted for 51.92% of total faculty in these programs. The three Behavior Analysis graduate programs identified here include the University of Nevada Reno, Western Michigan University, and the Florida Institute of Technology. There was a cumulative total of 35 faculty members, 22 were identified as male and 13 were identified as female. Females represented 37.14% of the total faculty in these programs. The top three Cognitive Neuroscience graduate programs include the University of Michigan—Ann Arbor, Harvard, and Stanford University. There was a cumulative total of 71 faculty members, 48 were identified as male and 23 were identified as female. Females account for 32.39% of the total faculty in these programs. The top three Biology graduate programs included the Massachusetts Institute of Technology, Stanford University, and the University of California—Berkeley. There was a cumulative total of 167 faculty members, 118 were identified as male and 49 were identified as female. Females accounted for 29.34% of the total faculty in these programs. The top three Physics graduate programs included the Massachusetts Institute of Technology, Stanford University, and the California Institute of Technology. There was a cumulative total of 182 faculty members, 159 were male and 23 were female. Females account for 12.64% of
the total faculty in these programs. With all programs combined, there was a total of 507 faculty members, 372 are male and 135 are female. As such, females accounted for 26.63% of the total faculty across all five fields. (See Table 10).

**Discussion**

Within behavior analytic approaches to the participation of women within the field, the majority of measures which have been analyzed fall under the distinction of scientific products; as a reminder, *scientific products* are defined as refined constructs resulting from the accumulation of scientific activities of an individual scientist or any number of scientists. Through an examination of novel measures of the participation of women, as they have been approached from the perspectives of fields outside of behavior analysis, it has been shown that many direct and indirect activities can be captured. Although many scientific products may appear as easier to (1) identify and (2) measure, they do not necessarily allow for meaningful or pragmatic changes or interventions to be identified. The construct provided in this thesis allowed us to identify relations between various indirect/direct activities and scientific products that may result from the accumulation of them.

This thesis extended the trend analyses of participation in the form of first author publications in three flagship behavior analytic journals. It also analyzed two products that are related to an individual publishing as first author; these include the credential of the first author as well as an analysis of gender distribution of faculty in the top graduate programs of various fields. For behavior analysis if we are to only consider the credentials of first authors within PBS, JEAB and JABA in the last five years, the
majority fell under the level of a PhD academician. JABA, the journal selected to represent the applied domain of behavior analysis, is the only journal that had a majority or near equal representation of females to males. Both PBS and JEAB had a smaller proportion of females at the PhD level. Overall, within behavior analysis a smaller proportion of women published than males and there is a higher proportion of men with the credentials of a PhD level academician than women. If those who are publishing within behavior analytic journals are doctoral level academicians and there are fewer females than males who are publishing, then it would only follow that there are fewer females than males who work at academic institutions as PhD level faculty members.

This is the case for behavior analysis. Of the faculty in the top three behavior analytic graduate programs that were analyzed, only 37.14% are females. The percentages of female faculty members across fields appear to map on to the conventional ranking of the sciences from least to most “scientific” or “hard” (Shermer, 2007; Wilson, 2012; Shukman, 2017) with a higher percentage of women faculty members in the perceived as less scientific fields (e.g. Clinical Psychology, Behavior Analysis, and Cognitive Neuroscience) and a far lower percentage of women faculty members in the perceived as more scientific fields (e.g. Biology, and Physics). Concerning the total number of faculty across all the fields, there was a disproportionate percentage of females as compared to males. With respect to all the fields included in this analysis, Clinical psychology was the only field where female faculty members outnumber male faculty members. However, to meet equal faculty membership would only be a difference of 1.92%, whereas in Physics, where males outnumbered females the most, to meet equal faculty membership would be a difference of 21.23%. As such, even
though female faculty members outnumber male faculty members in one field it is not by as significant of a difference as the field in which males outnumber females the most. (See Figures 10 and 11).

Here three scientific products that are interrelated were identified. We drew relations between the final product of first author publications, the credentials of those first authors, and the faculty positions at academic institutions. In all three categories, female participation fell short as compared to the participation of males. A goal of this thesis was to trace the relations between not only scientific products, but to the activities whose accumulation may lead to the development or reception of a scientific product. For example, if one were to continue down the path of identifying why more males publish than females in these three flagship behavior analytic journals then perhaps they could find where the participation of females in the field begins to fall off; the path we follow begins with the measures identified in this thesis (Publications>PhD Level First Authors>Faculty Positions). If one wanted to explore the distribution of gender among faculty further, they could investigate the terms of the faculty positions. Is the position full-time or part-time; have the professors received tenure or are they on a tenure track; who has been denied tenure; is it a position in a master’s degree program or a PhD program? These however are also all products. Some indirect activities related to these products were explored by the four fields, excluding behavior analysis, that were examined in the Novelty of Measures analysis.

Some of these indirect activities include, mentoring graduate students, teaching graduate level courses, lecturing as a guest speaker, conducting research abroad,
submitting research grants, serving on thesis or dissertation committees, serving on committees at a university, interviewing for tenure-track positions, writing for publications, performing research in a laboratory setting, designing research, etc. This analysis could also be brought down to the level of the student through an exploration of the distribution of gender among PhD recipients from behavior analytic graduate programs. If we were to find that more males were earning PhDs than females, then indirect and direct activities that are required in obtaining the final product of a doctoral degree could be identified and examined. Some examples of these were also explored with respect to other fields in the Novelty of Measures analysis; these included attending graduate courses, receiving mentorship, identifying research interests, frequency of asking questions during a class, frequency of answering questions during a class, frequency of attending lectures, amount of time spent studying, teaching undergraduate courses, participation at a conferences, etc.

**Implications and Future Directions**

As stated previously, scientific products initially appear easier to (1) identify and (2) measure, however they provide us with limited information concerning where and how to implement interventions. If a scientific product is identified and measured and it is found that there is a disparity in participation from males and females, it is here where the construct of scientific participation presented in this thesis comes of value. By tracing the relations between various products or activities and products we may begin to more readily identify where female participation is falling off and furthermore have evidence-based support as to where and how to intervene to increase participation by females.
Some potential implications can be made toward graduate training in graduate programs. A graduate program administrator could utilize a similar framework to evaluate the opportunities that are available to students of various genders who are working their way through or have completed their tenure within a program. An interested program would be encouraged to identify seven measures (e.g. one product and six related direct and indirect activities) and measure the current status of each of these. If the program were to identify inequity with respect to participation in any of these, they could take more well-informed steps toward providing more equal opportunities. These steps, of course, would be dependent on the program’s goals.

**Limitations**

There are several limitations that have been identified in the analyses conducted in this thesis. First, future research may consider utilizing a gender coding system that is non-binary. Currently most research examining participation in science codes for males and females only, however moving forward categorizing gender as only male and female may be problematic and limiting. Second, the Credentials of First Authors method did not have a standardized system regarding the order in which the various search criteria were entered. Rather, the selection of search criteria appeared to become quite random and seemed to be less efficient in identifying relevant documents. It is recommended that future research identifies an order of criteria that will lead to more efficient data collection (i.e. CV<theses/dissertations<Linked-in profile etc.). Third, many of the Faculty from Top Three Graduate Programs in Five Fields data depended upon the faculty listing on the webpages for the programs. There was no way to guarantee that the
information that was being gathered was current. Future research may consider contacting programs directly to gather the most accurate faculty information.
References


American Psychological Association. (1992). Graduate study in psychology. Graduate Study in Psychology,


http://dx.doi.org/10.1007/BF03391891


*Publication Number R-430.02*, American Institute of Physics.


Publication Trend Analysis across Three Behavior Analytic Flagship Journals: Results Summarized (N=8,857)

<table>
<thead>
<tr>
<th>Journal</th>
<th>Est.</th>
<th>F First Author</th>
<th>M First Author</th>
<th>Total F/M</th>
<th>Percent F First</th>
<th>Cross-over</th>
<th>Slope of Trend-line: y=</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBS</td>
<td>1976</td>
<td>178</td>
<td>929</td>
<td>1107</td>
<td>16</td>
<td>No</td>
<td>0.0015x + 0.8701</td>
</tr>
<tr>
<td>JEAB</td>
<td>1958</td>
<td>451</td>
<td>3,816</td>
<td>4,267</td>
<td>10.6</td>
<td>No</td>
<td>0.0039x + 8.5933</td>
</tr>
<tr>
<td>JABA</td>
<td>1981</td>
<td>1,147</td>
<td>2,336</td>
<td>3,483</td>
<td>32.1</td>
<td>Yes</td>
<td>0.0092x + 0.0635</td>
</tr>
<tr>
<td>All</td>
<td>n/a</td>
<td>1,776</td>
<td>7,081</td>
<td>8,857</td>
<td>20</td>
<td>No</td>
<td>0.0062x + 1.0127</td>
</tr>
</tbody>
</table>

Table 1. Each journal is indicated by the year it was established, the individual and total number of female (F) and male (M) first authors who were specifiable given our criteria, the percentage of F first authors, whether any cross-overs where women published at a higher proportion than men occurred, and the slope of the trend-line.

Measures of Women’s Participation from Peer Reviewed Articles in Behavior Analytic Journals (N=12)

<table>
<thead>
<tr>
<th>Indirect Activities</th>
<th>Direct Activities</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publications Accepted</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Publications Rejected</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Publications by Editors</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Editorial Board Appointments</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Professional Certifications</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Professional Awards</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Professional Conference Invited Speaker</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Conference Participation</td>
<td>•</td>
<td>-</td>
</tr>
<tr>
<td>Leadership Positions in Professional Societies</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maintaining Membership in Professional Societies</td>
<td>•</td>
<td>-</td>
</tr>
<tr>
<td>Fellow in Professional Society</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Faculty Positions Granted</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Number Per Form</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. The titles on the left specify the measures utilized in behavior analytic literature discussing the participation of women. The closed circles indicate which form of participation these measures are situated under.
<table>
<thead>
<tr>
<th>Scientific Field of Interest</th>
<th>Indirect Activities</th>
<th>Direct Activities</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior Analysis</td>
<td>2</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Clinical Psychology</td>
<td>43</td>
<td>3</td>
<td>42</td>
</tr>
<tr>
<td>Cognitive Neuroscience</td>
<td>25</td>
<td>0</td>
<td>43</td>
</tr>
<tr>
<td>Biology</td>
<td>14</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Physics</td>
<td>50</td>
<td>2</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>134</td>
<td>6</td>
<td>143</td>
</tr>
</tbody>
</table>

Table 3. The titles on the left indicate the scientific field of interest. The measures of participation were categorized with respect to the construct of scientific participation outlined in this thesis; indirect activities, direct activities and products.

<table>
<thead>
<tr>
<th>Scientific Field of Interest</th>
<th>Indirect Activities</th>
<th>Direct Activities</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Psychology</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Cognitive Neuroscience</td>
<td>2</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Biology</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Physics</td>
<td>2</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Total Shared</td>
<td>7</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 4. The titles on the left indicate the scientific field of interest. The measures of participation were categorized with respect to the construct of scientific participation outlined in this thesis; indirect activities, direct activities and products. Only the measures which were shared between the field of interest and behavior analysis are represented here.
Measures of Women’s Participation from Peer Reviewed Journals in Four Scientific Fields that are Novel to those Identified within Behavior Analysis (N=48 articles)

<table>
<thead>
<tr>
<th>Scientific Field of Interest</th>
<th>Indirect Activities</th>
<th>Direct Activities</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Psychology</td>
<td>42</td>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>Cognitive Neuroscience</td>
<td>23</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>Biology</td>
<td>13</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Physics</td>
<td>48</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Total Novel</td>
<td>126</td>
<td>6</td>
<td>111</td>
</tr>
</tbody>
</table>

Table 5. The titles on the left indicate the scientific field of interest. The measures of participation were categorized with respect to the construct of scientific participation outlined in this thesis; indirect activities, direct activities and products. Only the measures which were novel to behavior analysis are represented here.

Gender Distribution of First Author Publications on Women’s Participation from Peer Reviewed Articles Across Five Scientific Fields (N=57 first authors)

<table>
<thead>
<tr>
<th>Scientific Field of Interest</th>
<th>Total Male</th>
<th>Total Female</th>
<th>Total Male and Female</th>
<th>% Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior Analysis</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>66.67</td>
</tr>
<tr>
<td>Clinical Psychology</td>
<td>3</td>
<td>8</td>
<td>11</td>
<td>72.73</td>
</tr>
<tr>
<td>Cognitive Neuroscience</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>60.00</td>
</tr>
<tr>
<td>Biology</td>
<td>2</td>
<td>10</td>
<td>12</td>
<td>83.33</td>
</tr>
<tr>
<td>Physics</td>
<td>3</td>
<td>9</td>
<td>12</td>
<td>75.00</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>41</td>
<td>57</td>
<td>71.93</td>
</tr>
</tbody>
</table>

Table 6. The titles on the left indicate the scientific field of interest. The numbers listed within the three columns to its right represent the total count of male/female first author publications on the topic of women’s participation within the indicated field. The column to the far right represents the percentage of female first author publications.
### Table 7. Proportion of Male and Female Master's Level First Author Publications Across Three Behavior Analytic Journals (N=247)

<table>
<thead>
<tr>
<th>Year</th>
<th>PBS Male</th>
<th>PBS Female</th>
<th>JEAB Male</th>
<th>JEAB Female</th>
<th>JABA Male</th>
<th>JABA Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1.00</td>
<td>0.00</td>
<td>0.57</td>
<td>0.43</td>
<td>0.23</td>
<td>0.77</td>
</tr>
<tr>
<td>2015</td>
<td>1.00</td>
<td>0.00</td>
<td>0.50</td>
<td>0.50</td>
<td>0.30</td>
<td>0.70</td>
</tr>
<tr>
<td>2016</td>
<td>0.00</td>
<td>0.00</td>
<td>0.30</td>
<td>0.70</td>
<td>0.08</td>
<td>0.92</td>
</tr>
<tr>
<td>2017</td>
<td>0.50</td>
<td>0.50</td>
<td>0.23</td>
<td>0.77</td>
<td>0.18</td>
<td>0.82</td>
</tr>
<tr>
<td>2018</td>
<td>0.00</td>
<td>0.00</td>
<td>0.33</td>
<td>0.67</td>
<td>0.15</td>
<td>0.85</td>
</tr>
</tbody>
</table>

### Table 8. Proportion of Male and Female PhD Level First Author Publications Across Three Behavior Analytic Journals (N=851)

<table>
<thead>
<tr>
<th>Year</th>
<th>PBS Male</th>
<th>PBS Female</th>
<th>JEAB Male</th>
<th>JEAB Female</th>
<th>JABA Male</th>
<th>JABA Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>0.93</td>
<td>0.07</td>
<td>0.66</td>
<td>0.34</td>
<td>0.47</td>
<td>0.53</td>
</tr>
<tr>
<td>2015</td>
<td>0.46</td>
<td>0.54</td>
<td>0.80</td>
<td>0.20</td>
<td>0.42</td>
<td>0.58</td>
</tr>
<tr>
<td>2016</td>
<td>0.76</td>
<td>0.24</td>
<td>0.68</td>
<td>0.32</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>2017</td>
<td>0.85</td>
<td>0.15</td>
<td>0.95</td>
<td>0.05</td>
<td>0.58</td>
<td>0.42</td>
</tr>
<tr>
<td>2018</td>
<td>0.74</td>
<td>0.26</td>
<td>0.79</td>
<td>0.21</td>
<td>0.40</td>
<td>0.60</td>
</tr>
</tbody>
</table>
Male and Female Faculty from Top Three Graduate Programs across Five Scientific Fields (N=584)

<table>
<thead>
<tr>
<th>Field</th>
<th>Total Male Faculty</th>
<th>Total Female Faculty</th>
<th>Total Faculty</th>
<th>% Female Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Psychology</td>
<td>25</td>
<td>27</td>
<td>52</td>
<td>51.92</td>
</tr>
<tr>
<td>Behavior Analysis</td>
<td>22</td>
<td>13</td>
<td>35</td>
<td>37.14</td>
</tr>
<tr>
<td>Cognitive Neuroscience</td>
<td>48</td>
<td>23</td>
<td>71</td>
<td>32.39</td>
</tr>
<tr>
<td>Biology</td>
<td>118</td>
<td>49</td>
<td>167</td>
<td>29.34</td>
</tr>
<tr>
<td>Physics</td>
<td>159</td>
<td>23</td>
<td>182</td>
<td>12.64</td>
</tr>
<tr>
<td>All</td>
<td>372</td>
<td>135</td>
<td>507</td>
<td>26.63</td>
</tr>
</tbody>
</table>

Table 10. The column on the left indicates the scientific field of interest. The numbers listed within the three columns to its right represent the total count of faculty members from the top three graduate programs within each field. The column to the far right indicates the percentage of female faculty members.
Figure 1.
Figure 2.
Figure 3. Trend Analysis: Cumulative Record of Male/Female First Authorship within PBS 1978-2018.
Figure 4.
Figure 5.
Trend Analysis: Proportion of Male/Female First Authorship within JABA 1968-2018

Y = 0.0092x + 0.0035
R² = 0.8387
Figure 7.
Figure 8.
Figure 9.

Trend Analysis: Cumulative Record of Male/Female First Authorship across 3 Flagship Behavior Analysis Journals from 1958-2018
Figure 10.

Percentage of Male and Female Faculty Across Top Three Graduate Programs in Five Fields

- Clinical Psychology
- Sociology
- Behavior Analysis
- Cognitive Neuroscience
- Biology
- Physics

Figure 11.

Total Percentage of Male and Female Faculty Across Top Three Graduate Programs in Five Fields

- All 5 Fields

Male Faculty
Female Faculty