Convergent Validity of O*NET Holland Code Classifications

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The interpretive ease and intuitive appeal of the Holland RIASEC typology have made it nearly ubiquitous in vocational guidance settings. Its incorporation into the Occupational Information Network (O*NET) has moved it another step closer to reification. This research investigated the rates of agreement between Holland code classifications from three major sources. The Holland code classifications from the O*NET were compared with those from the Strong Interest Inventory and the Dictionary of Holland Occupational Types using six different methods. The mean pairwise rate of agreement for the first Holland code letter was 70.6%, with a three-way rate of agreement of 60.21%. The mean pairwise rate of agreement for the first and second Holland code letters was 32.33%, with a three-way rate of agreement of 15.71%. The mean pairwise rate of agreement for the first, second, and third Holland code letters was 12.56%, with a three-way rate of agreement of 2.62%. The implications of these findings for research and counseling practice are discussed.

Keywords: Holland types, Holland codes, RIASEC, person-environment fit, congruence, Strong Interest Inventory, Occupational Information Network, O*NET, Dictionary of Holland Occupational Types

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We acknowledge the helpful comments made by Dr. Itamar Gati on an earlier version of this manuscript.
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JOURNAL OF CAREER ASSESSMENT, Vol. 13 No. 2, May 2005 150–168
DOI: 10.1177/1069072704273124
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Until recently, researchers and practitioners alike have had two major sources of Holland codes to draw on. One of these was the Dictionary of Holland Occupational Codes (DHOC) (Gottfredson & Holland, 1996), the source of the Holland codes for the Self-Directed Search (SDS) Occupations Finder (Holland, 1994). The other was the Strong Interest Inventory (SII) (Harmon, Hansen, Borgen, & Hammer, 1994). With the incorporation of the Holland RIASEC typology into the Occupational Information Network (O*NET) (U.S. Department of Labor, 1998), the successor to the *Dictionary of Occupational Titles* (DOT) (U.S. Department of Labor, 1991), a third major source of Holland codes has emerged. Both the DHOC and the SII are well established in the vocational psychology literature. However, little has appeared in the literature regarding the validities of the O*NET Holland codes.

Unfortunately, there are no "gold standards" that can be used to access the veracity of the O*NET Holland code classifications. Indeed, considering the ongoing evolution of occupations and the nature of work, it seems unlikely that there will ever be definitive Holland code assignments for a given occupation, regardless of source (Gottfredson & Holland, 1996; Holland, 1997). Rather, we will likely always be in the position of making our best estimates regarding the nature of an ever moving target. Despite the somewhat transitory nature of these estimates, Holland code assignments are used to inform untold thousands of decisions regarding vocational choice and personnel selection. Given the significant consequences of such life-changing decisions, it seems of considerable importance to know how accurate Holland code "estimates" from a new source are. One possible method would be to compare the Holland code assignments of the O*NET with those assigned by well-established sources such as the SII and the DHOC.

Convergent Validity

The O*NET, the SII, and the DHOC each used very different methods to assign Holland codes to occupations. The O*NET used expert judgments. The SII used the most salient General Occupational Theme (GOT) scales for each of its normative occupational reference groups. The DHOC used an algorithm that was developed using DOT job description data. On the surface, these methods appear so dissimilar that some might question how much their respective classifications could be expected to agree.

One rationale for expecting at least a modest level of agreement lies in the concept of convergent validity (Campbell & Fiske, 1959). In their widely read and frequently cited paper, Campbell and Fiske argued persuasively for the importance of convergent validity in psychological assessment. Consequently, it is now a widely accepted principle in psychological test construction "that measures of the same variable made by different methods should agree (converge)" (Fiske & Campbell, 1992, p. 393). Although Campbell and Fiske originally wrote of convergent validity in terms of the psychological assessment of an individual, it does not seem inappropriate to expect that Holland code assignments for the same occupations, made by different methods, should agree with one another. Applying this principle to the issue at hand suggests that the Holland codes from the O*NET should agree with those assigned by the SII and the DHOC. Similarly, the classifications from the SII and the DHOC should also agree with one another.

It is clear that the developers of the DHOC, the O*NET, and the SII expected them to agree with one another. For example, in the introductory chapter of the DHOC, Gottfredson and Holland (1996, p. 14) state that the Holland codes contained in the DHOC "are expected to be compatible with (inventories other than the SDS and VPI)." However, they cautiously add that "no empirical tests of compatibility have been made."

The GOT scales of the SII were validated (in part) by administering both the SII and the Vocational Preference Inventory (VPI) (Holland, 1965) to a sample of 97 subjects (Hansen & Campbell, 1985). The same-named GOT scales and VPI scales were found to have a median correlation of .765, a value characterized as "indicating that the two inventories are measuring similar interest traits" (Hansen & Campbell, 1985, p. 31).

The O*NET interest profiles were validated by comparing its Holland code classifications for 36 occupations with those from the DHOC and the SII (Rounds, Smith, Hubert, Lewis, & Rivkin, 1999). The comparison between the DHOC and the O*NET found that 83.3% matched on the first code letter, 26.8% matched on both the first and the second code letters, and 12.5% matched on first, second, and third code letters. A mean Iachan's M of 23.58 was found between the O*NET and the DHOC. A mean M of 23.11 was found between the O*NET and the SII. Given that the Iachan Index has a range of 0 to 28 (Iachan, 1984), these values were interpreted as suggesting a fairly high rate of agreement between these three very different methods of assigning Holland codes.

As promising as these findings appear to be, one must resist the temptation to extrapolate beyond them to infer a high rate of agreement between the O*NET, the DHOC, and the SII. The O*NET developers only compared 36 occupations out of hundreds of possible comparisons. The finding reported by the developers of the SII reflects only the likelihood of obtaining similar Holland code profiles for individuals taking both the SII or the VPI. It does not reflect the different strategies used by the SII and the DHOC to actually assign Holland codes to occupations and what level of agreement one should expect to find between these classifications.

Therefore, it is the purpose of this article to present a broader empirical comparison of the rates of agreement between the O*NET, the DHOC, and the SII Holland code assignments. However, let us first briefly review the empirical literature comparing methods of assigning Holland code classifications.

Importance of Method

Research indicates that the method used to assign Holland codes can greatly affect outcomes. Much of this research was done using person-environment (P-E) fit modeling to operationalize the quality of the match between worker and workplace. Consistent with Schneider's (1987) argument that "people make the place," most researchers define workplaces in terms of the workers inhabiting them. Tinsley (2000) noted that one of the most common methods of assigning Holland codes to work environments is to use the occupational classifications found in the DHOC.

Lent and Lopez (1996) made a direct comparison of work environment codes obtained from the DHOC (Gottfredson, Holland, & Ogawa, 1982) and those calculated using the Environmental Assessment Technique (EAT) (Holland, 1985). Lent and Lopez found that the EAT method for assigning Holland codes allowed somewhat better predictions of job satisfaction than the codes found in the DHOC. However, they still considered the EAT to be far from problem free. Lent and Lopez reported inconsistencies between the codes assigned by the DHOC and the EAT and concluded "that the job coding method is much more important than has been recognized heretofore" (Lent & Lopez, 1996, p.33).

Assouline and Meir (1987) found that the method used to assign Holland codes to the work environment greatly affected the size of the correlation between P-E congruence and job satisfaction. In studies that used occupational group membership, the average correlation between congruence and satisfaction was .209. In studies that used the EAT, the average correlation between congruence and satisfaction was .291. Finally, in studies that used specialty within an occupation, the average correlation between congruence and satisfaction was .41. Clearly, the method of defining the environment can have a significant impact.

Unfortunately, other than the work of Lent and Lopez (1996), there has been little research systematically comparing the accuracy of the various methods used to assign Holland codes. Indeed, Rounds, McKenna, Hubert, and Day (2000, p. 207) lamented that P-E fit researchers "typically neglect to report how occupational type assignment is conducted and virtually never investigate how the occupational classification process might influence reported relationships."

Let us now review the methods used by the SII, the DHOC, and the O*NET to assign Holland codes to occupations.

Strong Interest Inventory

The SII, as originally developed by E. K. Strong, Jr., was composed of empirically derived occupational scales of outstanding psychometric properties but without an organizing theoretical framework (Harmon et al., 1994). As such, interpretations were limited to general statements concerning how similar a client's expressed preferences were to those of members of a given occupation. Strong attempted several organizational schemes, but none proved fully satisfactory and all were eventually discarded (Campbell, 1974). Finally, in response to this ongoing need, the Holland RIASEC typology was incorporated into the 1974 version of the SII.

The GOT scales were developed to assign Holland code classifications to both the SII occupational scales and to inventory users (Campbell, 1974). Six GOT scales were developed, one for each of the Holland types. Each GOT scale was developed by selecting 20 items from the existing SII item pool that reflected theoretically significant aspects of that Holland type. Subsequent revisions of the SII have refined the GOT scales (Harmon, et al., 1994). The modal GOT scores for each SII occupational scale reference sample serve as the starting point for assignment of Holland codes to each of the 211 occupational scales on the current version of the SII. Application of a set of decision-making rules results in each SII occupational scale being characterized by one to three Holland types. Interested readers are referred to the *Strong Interest Inventory Applications and Technical Guide* (Harmon et al., 1994, pp. 121-129) for the decision-making rules used by the SII developers for assignment of Holland types to each occupational scale.

Dictionary of Holland Occupational Codes

The DHOC (Gottfredson & Holland, 1996) is the fruit of an ambitious effort to assign Holland codes to the more than 1,200 occupational titles included in the DOT (U.S. Department of Labor, 1991). The authors of the DHOC accomplished this daunting task by using multiple discriminant analysis to develop a classification algorithm. The development sample included 189 occupational titles from the SDS Occupations Finder. There were roughly equal numbers of occupational titles representing each Holland type. The authors of the DHOC stated that they "selected occupational titles for which the evidence supporting the code assigned in the Occupations Finder appeared strongest" (p. 706). They did not elaborate further on the nature of this evidence. Starting with these 189 occupational titles, a classification algorithm was developed using 44 different job analysis ratings (available in the DOT) for each occupation. Interested readers are referred to the DHOC (p. 705) for a complete list of these job analysis ratings.

Gottfredson and Holland (1996) reported an 87.8% hit rate within the development sample when comparing the first code letter assignments of the algorithm with those of the authors. This classification function was cross-validated using a second sample of 296 occupational titles randomly selected from the DOT. These occupations were assigned Holland codes based on the expert judgment of the authors. A hit rate of 77.4% was obtained within the validation sample between the first code letter assignments of the algorithm and those of the authors. Satisfied with the validity of the classification function, the authors then used it to assign three-letter Holland codes to all of the occupational titles in the DOT. The most recent version of the DHOC (Gottfredson & Holland, 1996) contains classifications for 12,756 different occupational titles.

Unfortunately, closer examination of the information presented in the DHOC (Gottfredson & Holland, 1996, p. 707) suggests that the classification algorithm might not perform as well as Gottfredson and Holland believe. Random sampling of 289 occupational titles from the DOT for the cross-validation sample, very unequal numbers of occupations were obtained for each Holland type: 237 (82%) occupations were R theme; 7 (2.4%) were I theme; 2 (<1%) were A theme; 9 (3.1%) were S theme; 29 (10%) were E theme; and 5 (1.7%) were C theme. Although this distribution of Holland types is representative of the DOT as a whole, given the very low number of occupations representing the I, A, S, and C themes in the validation sample one can only be confident that the classification algorithm does a good job of classifying R types and that it might also perform satisfactorily with E types.

Meehl and Rosen (1955) suggested that one method to assess the efficacy of a classification technique is to compare its assignments against arbitrary classifications. In this light, it is discouraging to note that by arbitrarily assigning all 289 occupations as R theme, one would have been correct 82% of the time, an improvement of 4.6% over the validation sample hit rate reported by Gottfredson and Holland (1996).

Occupational Information Network

The O*NET initially attempted to derive its Holland code assignments by developing a classification function in a manner similar to that used by the authors of the DHOC (Rounds et al., 1999). Although these efforts resulted in an acceptable first letter hit rate, the classification functions assigned little or no weight to Holland code letters beyond the first. Consequently, the validity of the Holland codes assigned to positions 2 through 6 would have been very much in question. Rounds et al. suggested that the classification function used by the DHOC may suffer from a similar shortcoming. However, it should be noted that the efforts of Rounds et al. did not represent a complete replication of the model used by the developers of the DHOC. Gottfredson and Holland (1996) developed their algorithm using data representing individual occupational titles from the DOT. Rounds et al. developed their algorithm using data representing the Occupational Units (OUs) that the O*NET uses to cluster groups of similar occupations. The OU data used by Rounds et al. might be viewed as less precise than the data used by Gottfredson and Holland and consequently possibly gave rise to a less robust classification algorithm.

Given their failure to develop a satisfactory classification function and citing the DHOC's use of expert judgments as a "gold standard" against which to judge the performance of the classification function, the O*NET developers decided to simply use trained judges to assign Holland codes to each of the 1,172 OUs used to organize the O*NET (Rounds et al., 1999). A team of three trained judges were asked to rate on a 7-point scale how descriptive a given Holland type was of a given OU. A mean value for each Holland type was then calculated across the three raters. The Holland type with the highest value was assigned the first code letter position. The Holland type with the second highest value was assigned the second code letter position and so forth. Rounds et al. reported a Goodman-Kruskal gamma of .81, indicating a high degree of agreement between the three judges.

As discussed previously, the external validity for these classifications was assessed by comparing the rate of agreement between 36 representative OUs (6 from each primary Holland type) with classifications from the DHOC and the SII (Rounds et al., 1999).

METHOD

Matching Process

The occupations represented by the 211 occupational scales of the SII were chosen to provide a convenient starting point for this comparison of agreement rates between the O*NET, the SII, and the DHOC. The 211 occupational scales on the most recent revision of the SII represent a total of 109 unique occupations (Harmon et al., 1994). Of these 109 occupations, 102 have both male and female normed scales, 5 are normed only for females, and 2 are normed only for males. Unlike both the O*NET and the DHOC, the SII does not use standard DOT occupational titles. Therefore, the first step in comparing the SII with the O*NET and the DHOC was to match the occupational titles used on the SII with their equivalent titles from the most recent edition of the DOT (U.S. Department of Labor, 1991).

The first three authors met as a group to determine matches between the SII and the DOT. By using the descriptive information for the occupational scale reference samples found in the *Strong Interest Inventory Applications and Technical Guide* (Harmon et al., 1994), the authors were able to unanimously agree on matches for 100 of the 109 SII occupations with occupational titles listed in the most recent edition of the DOT. The authors were also unanimous in their agreement that 9 SII occupations had no clear equivalents in the DOT. These 9 occupations fell into two categories. The smaller category included occupations such as "elected public official" that had no similar occupational titles in the DOT. The larger category included SII occupations that represented more general groupings than the more specific titles listed in the DOT. An example of this is the SII occupational scale of "military enlisted personnel," for which no clear match could be found because the DOT listed military personnel by area of specialization (e.g., airborne sensor specialist, infantry operations specialist).

The next stage in this process was to use the DOT occupational titles and numbers now assigned to each of the SII occupational scales to match them with their equivalents in both the DHOC and the O*NET. Because the DHOC catalogs occupations using the DOT classification system, the process of assigning DOT occupational titles to the SII occupational scales also accomplished the task of matching SII occupational scales with their DHOC equivalents. As indicated previously, a total of 100 different occupations could be matched with their equivalents in the DHOC.

The O*NET Online database was used to identify matches between the SII occupational scales and the O*NET (United States Department of Labor, National O*Net Consortium, n.d.). The O*NET references occupations using DOT numbers and occupational titles, so many of the occupations were easily matched on that basis. However, the O*NET is a work in progress and not all of the 12,000 plus occupations listed in the DOT were included in its database, nor were all of the cross-linkages of the O*NET's indexing system in place, at the time of this data collection. Consequently, it was not possible to match all of the SII occupations with the O*NET by using DOT numbers and occupational titles. Fortunately, the O*NET is also indexed using the numbering system from the Standard Occupational Classification Manual (SOC) (U.S. Department of Commerce, 2000). Equally fortunate is that all of the occupational titles contained in the DHOC are also indexed using the SOC system, a feature that we were able to use to match additional SII occupations with their O*NET equivalents.

The first three authors met as a group to determine matches between the SII and the O*NET. By using both the previously determined DOT occupational titles for the SII occupations and the descriptive information found in the *Strong Interest Inventory Applications and Technical Guide* (Harmon et al., 1994), we were able to unanimously agree on matches for 102 of the 109 SII occupations with job titles included in the O*NET. We were also unanimous in our agreement that 7 of the occupations on the SII had no clear equivalent in the O*NET. As might be expected, these included 6 of the 9 occupations that we had previously been unable to match with DOT/DHOC equivalents.

In one instance, we "synthesized" an O*NET occupational title to enable a match with the SII. The SII contains the occupational scale "special education teacher." The reference group used to develop this occupational scale contained instructors in settings ranging from K through 12. However, the O*NET differentiates between special education instructors by the preschool, kindergarten, elementary, middle, and secondary school levels. Given that these O*NET occupations all shared the same Holland code, we felt secure in matching the SII occupational scale of "special education teacher" with a synthetic O*NET category called "special education teachers."

As the final step in the matching process, the first three authors met as a group to match occupational titles between the DHOC and the O*NET. We were able to unanimously agree on a total of 98 matches (out of a possible of 109 unique SII occupations) between the DHOC and the O*NET. (A complete list of the proposed matches across the three sources may be obtained by contacting the first author.)

Quantifying Agreement

Having matched the occupational scales on the SII with equivalent occupational titles in both the DHOC and the O*NET, we proceeded to quantify the rates of agreement for Holland code assignments between the SII, the DHOC, and the O*NET. Fortunately, the congruence indices that have been developed to compare Holland code profiles in the P-E fit literature are not specific to making comparisons between persons and environments. Mathematically, these formulas can be used to quantify the similarity between any two Holland code profiles, regardless of source.

This study used five different congruence indices to compare rates of agreement across these three sources: the K-P index (Kwak & Pulvino, 1982), the C index (Brown & Gore, 1994), Ichan's M index (Iachan, 1984, 1990), Gati's Sb index (Gati, 1985), and the First Letter Hexagonal Distance index (Holland, 1973). The specific formulas used for the calculation of each of these congruence indices are presented elsewhere in the literature and for considerations of space will not be reproduced here. Interested readers are encouraged to consult the primary sources cited here. As a sixth method of comparison, a simple tabulation of percentages of agreement was also calculated.

The K-P index and the C index were identified by Tinsley (2000) as being two of the three congruence indices that best operationalize the most important aspects of the Holland RIASEC typology. Mathematically, the K-P index and the C index are very similar. They differ primarily in that the C index operationalizes hexagonal distance using theoretical values and the K-P index uses empirically derived estimates of population parameters. Consequently, these indices tend to be very highly correlated with one another. However, in keeping with Tinsley's advice to include at least two of the three best congruence indices in any study, both were used here. The third index recommended by Tinsley, the hexagon congruence index (Swaney & Prediger, 1985), could not be used in this study because calculation of this index requires scale scores, data that were not available for the RIASEC classifications in the DHOC.

Although Iachan's M index (Iachan, 1984, 1990) does not operationalize the Holland model as well as either the C index or the K-P index, it was included to allow for comparisons between the results of this study and the O*NET validation work of Rounds et al. (1999).

The K-P index and the C index are calculated using the three highest ranking Holland codes for the profiles being compared. Iachan's M may be calculated using the two or three highest ranking Holland codes for the profiles being compared. Although the codes listed in the DHOC (Gottfredson & Holland, 1996) are always three letters in length, this is not the case with either the SII (Harmon et al., 1994) or the O*NET (Rounds et al., 1999). Both the SII and the O*NET use decision rules to determine whether a particular type is salient enough for a given occupational group to be included in its Holland code. The Holland codes for the SII occupational scales vary in length from one to three letters. The Holland codes for the O*NET occupational titles typically vary from one to three letters in length but in some instances are longer than three letters. To make comparisons between the Holland code classifications of the SII, the DHOC, and the O*NET, using the K-P index, the C-index, and Iachan's M, it was necessary to extend the classifications for the SII and the O*NET to three letters in those instances where they were shorter than three letters.

The extension of the codes for both the SII and the O*NET was accomplished by applying the same decision-making rules originally used by the developers of each for assigning Holland codes to occupations. In the case of the SII, all Holland code extensions were accomplished by applying the following two rules to criterion group information contained in the *Strong Interest Inventory Applications and Technical Guide* (Harmon et al., 1994):

1. Assign the Holland type with the next highest standardized scale score.
2. In the event of ties, assign the Holland type that would generate the greatest degree of consistency between the Holland codes assigned to the separate male and female occupational scales.

In the case of the O*NET, all Holland code extensions were accomplished by applying the following two rules to rating information contained in the O*NET Online database (United States Department of Labor, National O*Net Consortium, n.d.) and in the technical report Development of Occupational Interest Profiles for O*NET (Rounds et al., 1999):

1. Assign the Holland type with the next highest scale score.
2. In the event of ties, assign the Holland type that is nearest (in the hexagonal model) to the primary Holland code for the occupation.

(A complete list of the Holland code extensions may be obtained by contacting the first author.)

It could be argued that because the developers of both the SII and the O*NET chose to limit the number of Holland types used to describe an occupation to those that they considered most salient, a truer test of the congruence between these sources would be to make comparisons using only those Holland codes that were actually assigned by the developers. The only published congruence index that allows for comparison between Holland profiles of differing lengths is Gati's Sb index (Gati, 1985). Unfortunately, the Sb index is insensitive when comparing identical but out-of-order codes (Brown & Gore, 1994). This insensitivity to order was not an oversight (I. Gati, personal communication, October 20, 2002).

Gati's aspect-based approach to P-E fit does not consider the relative ordering of Holland types to be significant, and therefore sensitivity to order was not incorporated into the Sb index. However, as the only available congruence index that allows comparisons between Holland code profiles of differing lengths, the Sb index was used to make comparisons between the DHOC and "unextended" Holland code classifications from the SII and the O*NET.

Although the range, skew, and sensitivity of many of the more complex congruence indices are available in the literature (Brown & Gore, 1994; Camp & Chartrand, 1992), it is difficult for many readers to understand just how much congruence, in practical terms, is represented by a given score for a given index. A number of authors (Brown & Gore, 1994; Camp & Chartrand, 1992; Tinsley, 2000) have pointed out that the First Letter Hexagonal Distance (FLHD) index (Holland, 1973) does not operationalize important aspects of the Holland RIASEC typology, such as the circumplex hypothesis. However, because the FLHD index calculates congruence using only the first Holland code letter, it offers one significant advantage over more computationally complex congruence indices—intuitive ease of interpretation. Therefore, despite its shortcomings, the FLHD index was included in this study as an interpretive touchstone. In the same spirit, we also decided to report simple percentages of agreement between the three sources compared in this study.

RESULTS

The rates of agreement for Holland code assignments between the SII, the DHOC, and the O*NET were calculated using five different congruence indices: the K-P index (Kwak & Pulvino, 1982), the C index (Brown & Gore, 1994), Iachan's M index (Iachan, 1984, 1990), Gati's Sb index (Gati, 1985), and the FLHD index (Holland, 1973). In addition, as a sixth method of comparison, simple tabulation of percentages of agreement was also calculated. All of these comparisons were made using the separate male and female occupational scale Holland codes from the SII and the unisex codes from the DHOC and the O*NET. In an effort to provide readers with a familiar "real world" touchstone for levels of congruence, congruence was calculated between the SII male occupational scales (SII-M) and SII female occupational scales (SII-F) for each index. As indicated earlier, one of the decision rules used by the developers of the SII to resolve ties was to assign the Holland type that would generate the greatest degree of consistency between the Holland codes assigned to the separate male and female occupational scales. Because of this rule, congruence calculations between the SII-F and the SII-M are sometimes slightly inflated.

For all of the following fit indices, lower values represent less congruence and higher values represent greater congruence.

The K-P index (Kwak & Pulvino, 1982) has a range from 0 to 1. As might be expected, the highest K-P index value (.86) was found when we compared the

Holland code assignments of the SII-M with those of the SII-F. The lowest K-P index value (.62) was found when we compared the SII-F with the DHOC. The second lowest K-P index value (.65) was found when we compared the SII-M with the DHOC. All of the comparisons with the O*NET were intermediate in value (.69-.71).

The C index (Brown & Gore, 1994) has a range from 0 to 18. As would be expected, given the similarities between the C index and the K-P index, the same pattern of results emerged. The highest C index value (15.83) was found when we compared the Holland code assignments of the SII-M with those of the SII-F. The lowest C index value (12.02) was found when we compared the SII-F with the DHOC. The second lowest C index value (12.53) was found when we compared the SII-M with the DHOC. Again, all of the comparisons with the O*NET were intermediate in value (13.13-13.62).

Iachan's M index (Iachan, 1984, 1990) has a range from 0 to 28. As above, the highest M index (26.11) was found when we compared the Holland code assignments of the SII-M with those of the SII-F. The lowest M index value (19.62) was found when we compared the SII-F with the DHOC. However, in this instance, the comparison of the SII-M with the DHOC yielded the second highest M index value (25.88). As found previously, all of the comparisons with the O*NET were intermediate in value (22.59-23.22).

Gati's Sb index (Gati, 1985) has a range from 0 to 5. Here too, the highest Sb index (3.86) was found when we compared the Holland code assignments of the SII-M with those of the SII-F. The lowest Sb index value (2.37) was found when we compared the SII-M with the DHOC. The second lowest Sb index (2.42) was found when we compared the SII-F with the DHOC. The mean of the comparisons between the DHOC and the O*NET was 2.54. Again, the comparisons between the SII and the O*NET were intermediate in value (2.95-3.04).

The FLHD (Holland, 1973) has a range from 1 to 4. Consistent with the previous findings, the highest M index (3.89) was found when we compared the Holland code assignments of the SII-M with those of the SII-F, and the lowest M index value (3.34) was found when we compared the SII-F with the DHOC. The second lowest M index (3.41) was found when we compared the SII-M with the DHOC. Here too, all of the comparisons with the O*NET were intermediate in value (3.52-3.66).

In the final set of comparisons, simple tabulations were made of the percentages of agreement between the first letter, first and second letter, and first, second, and third letter Holland codes across the SII, the DHOC, and the O*NET. The now-familiar pattern of results, found by the more sophisticated fit indices, emerged here as well. In the comparison of percentages of agreement for only the first code letter, the highest rate of agreement (93.14%) was between the SII-M and SII-F. The lowest levels of agreement were between the SII-F and the DHOC (63.63%) and the SII-M and the DHOC (66.32%). Again, the levels of agreement between the O*NET and the SII-F, the SII-M, and the DHOC were intermediate in value (71.17-78.57%). The mean pairwise rate of agreement for first code letter (excluding the SII-F/SII-M comparison) was 70.6%. However, when comparisons are made across all three sources simultaneously, the rate of agreement falls to 60.21%.

When we compared the percentages of agreement for the first and second Holland code letters, the highest rate of agreement (72.54%) was again between the SII-M and SII-F. The lowest levels of agreement were between the SII-F and the DHOC (25.25%) and the SII-M and the DHOC (28.42%). Again, the levels of agreement between the O*NET and the SII-F, the SII-M, and the DHOC were intermediate in value (30.61-40.00%). The mean pairwise rate of agreement for first and second code letters (excluding the SII-F/SII-M comparison) was 32.33%. However, when comparisons are made across all three sources simultaneously, the rate of agreement falls to 15.71%.

Finally, when we compared the percentages of agreement for the first, second, and third Holland code letters, the highest rate of agreement (42.16%) was between the SII-M and SII-F. The lowest levels of agreement were between the SII-F and the DHOC (7.07%) and the SII-M and the DHOC (9.47%). Again, the levels of agreement between the O*NET and the SII-F, the SII-M, and the DHOC were intermediate in value (13.26-16.84%). The mean pairwise rate of agreement for first, second, and third code letters (excluding the SII-F/SII-M comparison) was 12.56%. However, when comparisons are made across all three sources simultaneously, the rate of agreement drops to 2.62%.

See Table 1 for a summary of these results.

DISCUSSION

On the surface, the levels of agreement between the O*NET, the SII, and the DHOC found by this study appear similar to those reported by Rounds et al. (1999). Rounds et al. compared the Holland codes of a small sample of O*NET occupational groups with those from both the DHOC and the SII by calculating Iachan's M. Rounds et al. reported a mean M of 23.58 (SD 4.55) between the O*NET and the DHOC and a mean M of 23.11 (SD 4.51) between the O*NET and the SII. This study found a mean M of 23.08 (SD 5.12) between the O*NET and the DHOC. This study found a mean M of 23.22 (SD 6.38) between the SII female scales and the O*NET and a mean M of 22.59 (SD 6.34) between the SII male scales and the O*NET. Rounds et al. also found a first letter agreement rate of 83.3% between the O*NET and the DHOC compared with the 78.6% rate found by this study. Rounds et al. found a first and second letter agreement rate of 26.8% compared with 30.6% found by this study. Finally, Rounds et al. found a first, second, and third letter agreement rate of 12.5% compared with 13.26% found by this study.

These results would seem to indicate an acceptable rate of agreement between the three classification systems. Unfortunately, as discussed earlier, there are no

Table 1
Summary of Congruence Index Values

	SII-F/SII-M	SII-F/DHOC	SII-M/DHOC	SII-F/O*NET	SII-M/O*NET	DHOC/O*NET
K-P index[a]	0.86 (0.17)	0.62 (0.25)	0.65 (0.25)	0.69 (0.25)	0.71 (0.25)	0.71 (0.23)
C index[a]	15.83 (2.61)	12.02 (3.86)	12.53 (3.72)	13.13 (3.86)	13.62 (3.76)	13.18 (3.61)
M index[a]	26.11 (3.47)	19.62 (7.99)	25.88 (4.44)	23.22 (6.38)	22.59 (6.34)	23.08 (5.12)
Sb index[a]	3.86 (1.32)	2.42 (0.99)	2.37 (0.88)	2.95 (1.31)	3.04 (1.35)	2.54 (0.97)
FLHD index[a]	3.89 (0.44)	3.34 (0.98)	3.41 (0.93)	3.52 (0.85)	3.55 (0.82)	3.66 (0.71)
1st letter[b]	93.14	63.63	66.32	71.17	73.68	78.57
1st & 2nd letters[b]	72.54	25.25	28.42	37.37	40.00	30.61
1st, 2nd, & 3rd letters[b]	42.16	7.07	9.47	16.16	16.84	13.26

Note. SII-F = Strong Interest Inventory female occupational scales; SII-M = Strong Interest Inventory male occupational scales; DHOC = Dictionary of Holland Occupational Codes; O*NET = Occupational Information Network.

a. First value represents the mean across all comparisons. The second value (in parentheses) is the standard deviation.
b. Values represent rates of agreement in percentages.

interpretive guidelines for existing fit indices. Consequently, it is difficult to know what level of agreement is represented by these M values. The meaning of the percentages of agreement is clearer. However, Rounds et al. (1999) only calculated percentages of agreement between the O*NET and the DHOC. When one moves beyond pairwise comparisons of the O*NET and the DHOC to comparisons involving all three systems, a more disappointing image emerges.

This study found a mean pairwise rate of agreement between the SII, the DHOC, and the O*NET of 70.6% for the first Holland code letter. This value dropped to a 60.21% rate of agreement when we compared across all three sources simultaneously. For first and second letter Holland code letters, the mean pairwise rate of agreement was 32.33% and the three-way rate of agreement was 15.71%. When we looked at the first, second, and third Holland code letters, the mean pairwise agreement rate was 12.56%, and the three-way rate of agreement was 2.62%.

Bandwidth Versus Fidelity

A consistent pattern of results emerged from the congruence calculations made by this study. The lowest levels of agreement were between the Holland codes from the SII and from the DHOC. In eight of nine comparisons, the lowest levels of congruence were found between the SII-F and the DHOC. In seven of nine comparisons, the next lowest levels of congruence were between the SII-M and the DHOC. Although the SII and the DHOC had lower levels of agreement with one another, they both had similar, and higher, levels of agreement with the O*NET. What might explain this pattern of results?

One possible way to frame this finding lies with the basic psychometric concept of bandwidth versus fidelity. In assessment, given limited resources, one may choose to measure either a narrower range in great depth (high fidelity) or a broader range more shallowly (wide bandwidth). Each of the vocational sources included in this study has reached a different compromise with this issue.

The SII represents the high-fidelity end of the continuum. Each of its 211 occupational scales was developed by comparing the responses of representative members of a given occupational group with those of “people in general.” Although the occupational groups on the SII were chosen to represent a broad swathe of the world of work, taken as a whole the SII contains only a very small fraction of the more than 12,000 occupational titles listed in the DOT.

The DHOC represents the wide-bandwidth end of the continuum. Its developers used an algorithm to assign Holland codes to the more than 12,000 occupational titles contained in the DOT. Although this methodology allowed codes to be assigned to the entire DOT, as mentioned earlier, the work of Rounds et al. (1999) suggests that the validity of codes beyond the first letter might be in doubt. In addition, the very unbalanced distribution of Holland types in the DHOC cross-validation sample raises some doubts regarding the accuracy of its classification of types other than R and E.

The O*NET may be viewed as falling somewhere in the middle of the continuum. Each of the 1,172 occupational units in the O*NET were assigned Holland codes by a team of judges following review of an extensive body of occupational group information collected by the U.S. Department of Labor for classification purposes. Although such a system does not have the fidelity of the SII methodology, it also does not have the bandwidth of the DHOC methods. However, by occupying the midpoint on this conceptual continuum, the O*NET is in a position to have more in common with either of the endpoints (the SII and the DHOC) than either has with one another. In this context, it makes sense for the SII and the DHOC to each be more congruent with the O*NET than they are with one another.

Shortcomings of Existing Fit Indices

It has also become clear from this study that we have yet to arrive at the ideal fit index. Although the K-P index and the C index both operationalize the most important aspects of the Holland RIASEC typology (Tinsley, 2000), both must be calculated using three Holland code letters. In many instances, the Holland codes from the SII and the O*NET needed to be "extended" to three letters to allow calculations of congruence. Both the SII and the O*NET use decision-making rules to determine how many Holland code letters are needed to describe the characteristics of an occupational group. By "extending" the codes from either of these systems to three letters in length, one is adding and giving weight to information that the developers have already determined to be of minimal importance. At best this additional information will only minimally improve estimates of fit. At worst, it may actually be lowering estimates of fit by adding information with no predictive value to the calculation. Gati's Sb index can make comparisons between codes of differing lengths. Unfortunately, as discussed earlier, the Sb is insensitive to identical but out-of-order sets of Holland codes. Taken together, this suggests that work needs to be done to develop a fit index that will combine the strengths of the C index with the Sb index's ability to compare Holland codes of differing lengths.

Practitioner Concerns

An additional shortcoming of current fit indices is the lack of interpretive guidelines. Knowing the range of possible values for a given fit index and that higher values mean better fit than lower values, one is left to exercise one's best judgment. Attempting to generate and apply one's own "rules of thumb" in this manner is further complicated by the skewed distributions of most fit indices (Brown & Gore, 1994). The lack of interpretive standards for fit indices represents an inconvenience to researchers but prevents the meaningful use of these fit indices for counseling purposes.

It is the experience of the first three authors that in many career guidance settings, clients "mix and match" career resources using Holland types. In a fairly typical scenario, a client is administered an interest inventory, such as the SII, and prominent among the results is information that can be used to assign a Holland type to the client. Recognizing that the limited number and range of occupations listed on the SII should only represent a starting point for a client's occupational explorations, counselors frequently direct their clients toward more exhaustive career resources, such as the DHOC and the O*NET—resources that use Holland codes to characterize occupations. Clients are told to use their Holland type (from their interest inventory results) as the key to unlock these other systems. However, given the relatively low rates of agreement between the three systems investigated by this study, it seems possible that this strategy could lead to confusion or inappropriate career choices.

Study Limitations

This study should only be seen as a starting point for the investigation of agreement rates among Holland code sources. The 109 occupations from the SII were used as a convenient starting point. Depending on the comparison being made, the organizational differences between the DHOC, the O*NET, and the SII only allowed pairwise comparisons to be made using a smaller number (98-102) of the occupations. Both the DHOC and the O*NET contain many hundreds of additional occupations not represented on the SII and for which no comparisons were made in this study. In addition, it is a common criticism of the SII that it is skewed toward occupations requiring a college education and as such does not represent a balanced cross-section of the entire world of work. Consequently, the agreement rates found by this study may be somewhat different than would be found from comparing a more representative cross-section of occupations or from comparing the large number of additional occupations contained in both the DHOC and the O*NET.

The results of this study might also be limited by the need to "extend" some the Holland codes of both the SII and the O*NET to three letters so those fit indices that best operationalize the most important aspects of Holland's RIASEC model could be used. As discussed earlier, these extensions might actually be reducing estimates of congruence by the introduction of "noise" into a given Holland code.

Finally, although we attempted to exercise due diligence in the process of matching occupational titles between the DHOC, the O*NET, and the SII, it is possible that other groups might have reached somewhat different decisions.

CONCLUSIONS

Overall, the results of this study are disappointing. The SII, the DHOC, and the O*NET disagree on first letter code assignments about one third of the time. Consequently, we may be unsure of the correct first letter classification for an occupational group up to a third of the time, and career guidance clients may be basing a life decision of critical importance on faulty information.

Each classification system represents a different compromise with the issue of bandwidth versus fidelity. Although the Holland code classifications of the SII (developed using the reference sample for each occupational scale) might be viewed by some as having the highest fidelity, the SII also includes the smallest number of occupations. In addition, the SII uses non-DOT occupational titles, making it more difficult to link SII results with other occupational classification systems. Future researchers would benefit greatly if the SII occupational scales were brought into agreement with occupational classification systems such as the O*NET.

Further investigations of patterns of agreement and disagreement of Holland code assignments are needed, particularly between the O*NET and the DHOC. Research is needed to empirically determine the relative importance of the first, second, and third letters of Holland codes. A congruence index is needed that combines the strengths of the C index with the ability of the Sb index to compare Holland codes of different lengths. Furthermore, the development of interpretative guidelines for congruence indices would benefit both researchers and counselors.

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