HAND USE, PREFERENCE AND PROFICIENCY: A CROSS-CULTURAL COMPARISON OF KWAKIUTL AND CAUCASIAN SAMPLES

by

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ABSTRACT

A cross-cultural comparison between 180 Kwakiutl and 180 Caucasians, matched for age, gender and geographic location, revealed significant differences in the distributions and proportions of handedness behavior as measured by hand use and preference questionnaires and a proficiency task. The Kwakiutl consistently demonstrated less right-handedness and a greater degree of ambi-handedness on all measures. Both groups performed equally well with their left hands on the Hand Proficiency task but the Caucasians were better with their right hands. The difference score (R - L) on this task was significantly smaller for the Kwakiutl, indicating that the Caucasian sample had greater proficiency of the right hand. Age by culture effects (age 4 to 6, 10 to 12, adult) were examined to investigate environmental pressure or differing developmental patterns across cultures. The Kwakiutl pattern over age was an inverted U. Lesser degrees of right-handedness were seen in the ages 4 to 6 and adult groups, but a large increase occurred during the school years of age 10 to 12. The Caucasian pattern was J shaped, indicating an increase in right hand use with increasing

age. These results support predictions from a number of theoretical orientations that suggest that cross-cultural differences in handedness behavior may arise from genetic, environmental or developmental differences.

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STATUS AND DEFINITION OF HANDEDNESS

The study of handedness has fascinated many researchers over the past century. Historically, a large majority of mankind have reportedly been right-handed regardless of the era or culture sampled (Porac and Coren, 1981). The basis of right-handedness has long been a subject of controversy. Environmentalists avow that societal demands and practices are responsible for the predominance of right-handers. Geneticists argue that some mechanism or specific gene is inherited since the incidence of right-handedness is relatively invariant across populations and thereby independent of socio-cultural bias. In an attempt to clarify these positions, much research has focused on the deviant aspect of handedness behavior. Left hand use has historically been construed as deviant and, because of its limited although persistent occurrence, has attracted the attention of a large number of investigators. In fact, many societies consider left hand use to be evil, disrespectful or a sign of illness (Hertz, 1960). Surprisingly little consideration, however, has been given to ambi-handedness

which is reportedly less frequent than left-handedness. Several authors have offered personal statements on the advantages of such behavior (Jackson, 1905; Baden-Powell, 1905) and suggested that it be encouraged in the general population. Their advice received little attention.

Two assumptions underlay the earlier studies of handedness behavior. The first, that handedness was a unidimensional variable, led investigators to classify individuals as either right- or left- handed. Subjects were assigned to groups on the basis of a single observation or response, without regard for consistency over a number of items. This traditional approach precluded the investigation of the distributional quality of handedness where, when a number of different items are reported on, the strength or consistency of handedness behavior can be determined. As well, the majority, when sampled on a larger number of items, tended to have some left-handed responses. Thus, a degree of mixed handedness is often the rule rather than consistent right-handedness. This mixed handedness may be construed as an ambi-handed quality or having the ability to use either or both hands in the execution of certain manual activities. When populations are compared on the basis of strength or consistency distributions, different patterns may emerge in this mixed range. Therefore, when

one is looking for differences across cultures, subcultures or time eras, this mixed part of the distribution may be very important in discriminating between such populations. Other research supports this variation in the mixed range. Right-handed women tend to be the most consistent or most right-handed in their responses (Bryden, 1977) while epileptic and mentally retarded populations are less consistent (Porac, Coren and Duncan, 1980).

The second assumption, that handedness behavior does not differ significantly across cultures and eras, has not yet been adequately put to test. Most investigations concerning cross-cultural populations have utilized a unidimensional concept of handedness behavior and have categorized their observations as either/or phenomenon. Reporting the handedness distributions may well yield different results across cultures. Both of these preceding assumptions will be challenged in the following thesis.

Handedness is a difficult term to define with consistency as investigators report on those aspects which reflect their particular interests. Current research has identified three basic factors which constitute handedness behavior in man. These include hand preference, proficiency and strength.

Preference refers to the hand which is preferred for performing a specific task, but it does not imply that this hand is stronger or more proficient in an equivalent behavioral measure of that task. Thus, many left-handers prefer to use their left-hand when opening a jar but have superior grip strength in the right hand (Provins and Cunliffe, 1972). Proficiency refers generally to measured manipulative ability, dexterity or speed in the execution of a fine motor task such as finger tapping, peg placement or handwriting. It is usually assessed on a timed performance trial, but has been inferred by use of questionnaire items which involve fine motor skills such as writing hand, sewing hand, dialing hand, and so forth. Strength or gross motor control refers to absolute strength as measured by performance. Hand grip strength, for example, is commonly determined by performance on a dynamometer. Strength differs from proficiency and preference although these three components are often consistent in right-handers.

Other dimensions of handedness include the dominant/nondominant classification where the hand performing the action is construed as dominant and the hand in the holding or supportive role is the nondominant. The unimanual/bimanual distinction, first proposed and documented by Koch (1933) involved the division of manual

tasks into categories depending upon whether the requirements were met by the predominant use of either the right or left hand or the simultaneous cooperative use of both hands.

Right- or left- handedness is currently determined by the superior performance or greater preference on a number of items (or on a single item). When a questionnaire is used, a greater number of right-handed responses indicates right-handedness and conversely for left-handedness. Ambi-handedness has been loosely defined in the current literature as either mixed handedness or as weak right- or left- handedness. However, there are several meanings embodied by this construct. It could be interpreted as the ability to use either hand with the equivalent degree of strength or finesse for the same task. It could represent the ability to perform several tasks with the right hand and an equal number of different tasks with the left. Finally, it may also be construed as the combination of both of these types of handedness behavior. Because little information is available on the incidence of either type, a combination of both possible definitions will be considered ambi-handed behavior for the present purpose.

HISTORICAL CONTEXT

Historically, the advent of Christianity brought about the first written documentation of hand use (eg. Judges 20: 15-16 lists the distribution of left- and right- handedness in the Benjamin and Gibean armies), but its occurrence as a predominant behavior in human societies predates this era by at least several centuries. According to Dennis (1958), who investigated Egyptian art-forms from approximately 2,500 B.C., and Coren and Porac (1977), who reported on handedness in artforms across several cultural groups dating from 3,000 B.C., human populations have been right-handed for at least Five Millenia. Parello (1970), however, using the Draw-A-Man Test, found that ancient paleolithic man was probably either more ambi-handed or left-handed to a greater degree than reports from later time periods have indicated. Reinhold (1963) also reports that Stone Age Man (20,000 to 10,000 B.C.) showed no definite laterality according to inferences drawn from the shape of stone implements, arrow heads and spearheads. It was not certain whether Stone Age man used either hand with equal skill or whether half the population was right-handed and half left-handed (p. 203). However, a marked shift towards right-handedness occurred in the Bronze Age (3,000 to 2,000 B.C.) as shown by exclusive manufacture of the sickle for right hand use. Reinhold

(1963) concluded that the incidence of right hand preference has further increased since that time. This apparent change in handedness patterns over eras may be explainable in terms of an anthropological perspective based on Darwinian evolutionary theory. The earliest hominid species may not have had a dominant, manipulative hand since tool use apparently did not occur until later in human evolutionary history. However, as survival depended increasingly on hunting skills, the manufacture and use of weaponry became an integral part of daily life. Those who became more skilled at the construction and use of such tools enjoyed a growing efficiency and manipulative capacity in one hand for certain types of tasks. As each became more successful in hunting for food and in defending their families, this proficiency may have been passed on resulting in a slow but increasing percentage of unimanual members. Huheey (1977) also reports that the origin of handedness is to be found in the early hominid stage, at the onset of tool use on an extended basis. He came to this conclusion after finding that anthropoid apes were either ambi-handed or had poorly defined dextrality while Australopithecus was clubwielding and predominantly dextral. Thus, lateral behavior was reportedly fixed prior to the use of the spear and shield. However, Carlyle's (1865) warfare theory of combat and shield protection contended that lateral behavior arose as a

consequence of the use of the spear and shield. This paternal-environmental theory argued that right-handers were favored in combat because their right-handed weapons were closer to their opponents' vital parts and that carrying a shield in their left hand protected their vital areas. Huheey (1977), in his argument against such a theory, proposed rather that right-handedness began with the mother's influence such that "in early hominid evolution, tool use and manual efficiency became predominant factors, and strong selective pressures existed for dextral mothers who, holding their infant in the left arm, could perform increasingly complex tasks with the right free hand" (p. 306). Current investigations support this rationale as nearly 80% of all mothers hold their newborn infants against a point to the left of the body midline (de Chateau and Andersson, 1976).

The method of establishment of human right hand use remains unclear and such theories are interesting but provide little direct evidence for or against selection theory. Right-handedness occurs in some 86 to 99.5 % of the populations sampled thus far indicating cross-cultural variation of at least 13.5%.

The earliest cross-cultural theory of handedness was presented by Brinton in 1896. He advocated the then

controversial evolutionary position that "savage races and primitive men presented greater evidence of left- and both-handedness than modern, civilized peoples" (p. 175). His arguments were based on archaeological, linguistic, environmental and physiological observations. For example, of 200 flint blades recovered in North American digs, 138 or 67% were fashioned with the right hand while 33% were formed with the left or both hands. He also reported that references to the left-handed members of Native American tribes were not infrequent in their languages, and their terms for left had "not the sinister sense attached to them which we find in most Aryan tongues" (p. 176). For example, in the Cree language, the left hand was called 'namatinisk' and 'nama' meant no or not. In current Kwakwalla, the Kwakiutl language, this distinction still occurs. The left arm is denoted by ''kum-howilts-e-ya-paie' which means simply not the right arm, and 'gen-xutc'ana' which means not the right hand (Shaugnessy, Note 1). Brinton (1896) suggested that this simple negation rather than the sinistral or derogatory terms found in Aryan references indicated perhaps a greater tolerance for left-sided use in North American Indians. Furthermore, Brinton (1896) described the erect human stature as the physiological basis of right-sidedness. He proposed that blood flowed along a shorter course and in less time from the heart to the left

brain, encouraging an advantage on the contralateral side of the body. This advantage was more fully realized in an educated society where the demands of skill were greater, thus "specialization of the hands was less in savage conditions" but a right majority existed. This physiological and environmentalist explanation also attempted to account for the crossed anatomical nature of the nerve fibres from the left hemisphere to the right hand.

However, Brinton's evidence was subjected to a frequent and prolonged controversy by his colleagues who discounted the flint blades as they may have been the work of a few skilled blade makers rather than individuals (Wilson, 1891) and the linguistic interpretations which appeared to be dependent upon the particular translator's whim or ingenuity (Wilson, 1891). It was agreed, however, that education was instrumental in increasing the number of right-handers (Wilson, 1891; Sully, 1895; Brinton, 1896) as 25 % of the five-year-old children sampled failed to demonstrate a consistent preference while older children did. This difference was attributed solely to the effect of education rather than the, as yet, unrecognized influence of development or maturation.

Unfortunately, Brinton's (1896) evidence was circumstantial, as was that of Dennis (1958), Parello (1970)

and Coren and Porac (1977). No direct test of Brinton's (1896) cross-cultural evolutionary theory has yet been conducted. This would have entailed a relatively simpler procedure in his time, as larger remnants of aboriginal peoples still remained isolated from the influence of immigrating Europeans. A counting procedure based on hand use items and proficiency measures would have provided an adequate record of the actual handedness patterns. This would have been considerably more accurate than determining such distributions on the basis of whether flints were carved with the right or left hand or which way a profile faced on a cave wall (Parello, 1970).

CONTEMPORARY CROSS-CULTURAL RESEARCH

A relatively small selection of contemporary cross-cultural research concerning handedness behavior exists. This is surprising as such investigations offer an opportunity to test the limits of environmental and societal influences on such behavior (when a common genetic mechanism can be assumed). By assigning one population as a control and comparing another's cultural, environmental and/or genetic variables against it, hypotheses concerning the mechanisms of handedness can be generated and tested.

Porac and Coren (1981) have summarized the studies on handedness in different cultures since 1950 and these appear in Table 1. The majority of these studies are regretfully tangential to the the cross-cultural difference hypothesis of the present investigation but do serve to illustrate the variation in the percentages of right-handedness across cultures. The handedness percentages reported also reflect the particular dimensions which interested each group and consequently, some of the differences in the table may reflect variation in measurement technique rather than cultural variation. However, the inspection of these studies does reveal considerable differences between the populations sampled. Scottish children have the greatest incidence of left-handedness (14 %) while Kantanganese children have the least (.5 %). Many of these investigations did not address a particular theory of handedness but merely reported the incidence of right-handedness in different population samples. However, the substantial differences across cultures and age groups within cultures did warrant the further concern of several investigators.

For example, Pelecanos (1969) assessed the handedness of Greek children, aged 10 to 12, in an attempt to find out initially if any relationship existed between handclasping and arm folding behavior and secondly, if the frequency of right- and left- types of individuals differed over age. Hardyck, Goldman and Petrinovich (1975) examined handedness with respect to gender, race and age and concluded that the differences between groups were primarily culturally determined. Teng, Lee, Yang and Chang (1979) compared the handedness of a Chinese sample of students to other Caucasian samples and found no difference. In an earlier study, Teng, Lee, Yang and Chang (1976) reported that attempts to increase right-handed writing and eating by social pressure were successful. This effect did not transfer to any other activities. Rhoads and Damon (1973) reported that for hand clasping no age, gender or tribal differences were found between four Solomon Island populations. They also concluded that handedness in the Solomon Island samples did not differ from other reported Caucasian samples. Dawson (1972, 1977) reported handedness percentages for several cultural groups. In addressing a social pressure conformity hypothesis, he found more left-handed Eskimos and Australian Aborigines and fewer left-handed Temne and Chinese Hakka. His explanation for such a

suppression of left-hand use, as Verhaegen and Ntumba (1964) report. The Maori attend to left and right only for ritualistic behavior, where the left is bad and the right good (Porac and Coren, 1981). North American societies reportedly tolerate or ignore left-handedness while some European cultures resorted to binding the left hand to induce the use of the right hand for writing purposes during early schooling.

Dawson (1977) argued that hunting societies, because they value independence, have extremely permissive socialization practices and, therefore, lower degrees of conformity that result in a lower percentage of right-handedness. Agricultural societies, which are larger and consequently require a higher degree of social organization, have stringent conformity requirements resulting in a greater percentage of right-handedness. Dawson's (1972, 1977) research on the Temne (agricultural) and the Eskimo (hunting) as well as on two Hong Kong samples reveals an 8 % increase in right-handedness in agricultural societies when compared to hunting societies. However, Dawson's (1972, 1977) theory is not limited to environmental aspects in the determination of handedness. A genetic interaction with the degree of conformity demanded by the particular society is also encompassed within his viewpoint (which will be discussed in a following section).

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handedness at conception which is later influenced by the environment, age, gender and neurological variables.

Thus, cross-cultural variation in handedness can be hypothetically explained as a product of the complex interactions of environmental pressures (in the form of cultural demands) which may differ in their effect on the particular developmental or maturational characteristics within each group. There is a given base rate for right-handedness of 70% which may be influenced also by environmental constraints (isolation and size of the cultural group) to a certain degree prior to conception. Each of these theories and their possible influence on handedness behavior will now be considered in greater detail.

ENVIRONMENTAL OR SOCIAL PRESSURE THEORIES

The first premise, social pressure, is a reasonable possibility as many cultures reportedly differ with regard to their tolerance of left-sidedness. Historically, the left is associated with evil, illness and disrespect (Hertz, 1960). The Bakitara of Africa, for example, despise left-handedness and plunge children's arms into boiling water to discourage use of the sinistral side. This technique and lack of tolerance appear to be very successful in the

Other social pressure theories have addressed the handedness behavior of the human infant. Prior to the concept of development and maturation, it was assumed that if handedness was dictated by socio-cultural practices, infants would show no preference. Baldwin (1890) and several others documented their children's handedness behavior from infancy until the occurrence of a strong behavioral preference for one hand. Mixed results were obtained with periods of both left- and right- handed behavior. Watson (1925) also measured infant body structures for asymmetries to explain a right or left preference but no such differences were encountered. He also found no consistency in hand use when reaching for candies at age one. He concluded that right-handedness was due to social pressures but could not explain the small but consistent incidence of left- and ambi- handedness in adults. These early social pressure theories were inadequate as they did not attempt to account for developmental or maturational influences on handedness behavior.

DEVELOPMENTAL OR MATURATIONAL THEORIES

Several investigators have reported that hand preference in the general population shows an increase with age toward

the right side (Coren and Porac, 1981; Gesell and Ames, 1947). Of these, Gesell and Ames (1947) were the first to summarize the major forms of handedness from infancy to age 10 in a longitudinal study. They reported that phases of left-handedness, ambi-handedness, bilateral movement and right-handedness were common to all individuals. The rate at which an individual moved through such phases depended on the maturation and development of the central nervous system as well as on environmental influences including deprivation, cultural differences and gender.

Porac, Coren and Duncan (1980) summarized the surveys published on handedness and other lateral preference behaviors over the last ninety years with regard to age trends (see Table 2). Their results coincide with Gesell and Ames's (1947) study. An increase in right-handedness of 12.8% occurs between infancy and elementary school with a slight dropoff of .4% from elementary school to adulthood. Whether this dextral increase is dependant upon the environment (social pressure and practice) or upon the developmental expression of a genetic mechanism remains unclear. It is most likely due to a complex interaction of both factors.

At the other end of the age continuum, Fleminger, Dalton and Standage (1977) have concluded that increased age

TABLE 2

AGE TRENDS FOR HAND PREFERENCE SUGGESTED BY A SURVEY OF PUBLISHED STUDIES (PORAC, COREN & DUNCAN, 1980)

AGE RANGE OF SAMPLE	NUMBER OF STUDIES	RIGHT-HANDEDNESS (MEAN%)
Infant	3	79.9
Preschool	4	82.6
Elementary school	24	92.7
High school/college	15	90.0
Adult	20	92.3

is associated with greater consistency or strength in dextral performance. They reported a 23% increase in fully dextral subjects from age 15 to 64. Similarly, Porac et al. (1980), whose North American sample ranged from age 8 to 100, reported that the proportion of their sample classified as right-handed increased with chronological age. Levy (1974) suggested that cultural pressure may be responsible for these age trends of increased right-handedness. In 1930, only 2.2% of the American population sampled was left-handed while from 1960 to 1980 at least 10% were left-handed. They accounted for this asymptotic difference by reflecting that during school years in the 1930's, right-handed writing was strictly enforced. It is supposed that, at present somewhat more deviation is tolerated. Thus, the increasing preponderance of right-handers in the older population may have been subjected to more extreme environmental pressure to use their right hands for writing during their developmental formative years.

In discrete cross-cultural milieus, it is possible that socio-cultural pressures may influence handedness behavior differentially. If this were so, one would expect the maximum difference to occur during the age where these pressures were greatest which would be during school years or training periods. Therefore, if one were to

appropriately test such a hypothesis, several age levels would be required. In effect, a pre-test, post-test and an experimental group would be necessary. The pre-test group would have to include those not yet exposed to the social pressure. The experimental group should include those who had been subject to the social practices in question for several years. The post-test group should include those who had completed training and who had returned to their pre-experimental cultural milieu for some time. In this way, if one assumes that the developmental and maturational stages as well as the genetic factors are equivalent across cultures, the effects of socio-cultural pressure during development may be assessed.

GENETIC THEORIES

Gene pool theory is a complex and fascinating area of investigation which may offer some explanation of the differences in handedness distributions across cultures. Annett (1964, 1967, 1972) originally proposed a genetic model of handedness in which the allele 'D' manifested right-handedness and was usually dominant. The allele 'R' was recessive and manifested left-handedness and a partial penetrance of 'R' occurred in heterozygotes. Left-handedness was seen to be influenced by an imperfectly

recessive gene. Annett (1964, 1967, 1972) further suggested that the distributions of left- and right- handedness in the Western and United Kingdom populations were 0.64 for dominant homozygotes, 0.32 for heterozygotes and 0.04 for recessive homozygotes. The actual expression was influenced by many factors including age, gender and defects of the central nervous system. In 1978, Annett refined this position to that of a single gene model for handedness. In this genetic right-shift model, an inherent tendency to use the right hand is dominant and right-handedness is the underlying expression. Handedness and cerebral language organization are related by a single gene which is responsible for a right-shift in the developing organism. This factor is responsible for left-hemisphere speech and right-handedness arises as a by-product. (The relationship of handedness and speech lateralization is beyond the scope of this paper). The gene has one directional allele which is a bias to the right. If absent, then random or accidental factors dictate handedness and produce a normal distribution in the population with a rightward bias. If no right bias is inherited, an individual becomes either left- or ambi- handed, depending upon environmental factors. Porac and Coren (1981) suggest that it is the strength or consistency of handedness which is inherited. This position is congruent with Annett's (1978) theory. Thus, handedness

may be viewed as a continuous rather than dichotomous variable with right- and left- handedness at the extremes.

Dawson (1977) was the first to articulate and test a genetic-environmental hypothesis. He argued that cultural pressures toward conformity would increase the predominance of right-handedness, altering Annett's genetic model of cerebral-hand distribution in a predictable direction. The precise incidence of left-handedness in different societies is held to be influenced by the biological constraints of the ecosystem which determine the type of socio-cultural environment and its consequent social norms. More specifically, Dawson (1977) confirmed the following two hypotheses embodied in his model. The first hypothesis contended that "the incidence of left-handedness in a society is selectively determined both by a postulated modification of Annett's (1964) cerebral dominance model and cultural pressures towards conformity" (p. 124). The second hypothesis emphasized the social pressure effect and stated that "because of the higher pressures towards conformity in the agricultural Temne and Hakka societies, the incidence of left-handedness would therefore be much lower than among the Arunta and boat people, hunters and fishermen, who have more independent, less conforming attitudes required for survival in snow and desert ecologies" (p. 124-125).

In summary, the current status of the conformity, developmental and genetic theories with regard to cross-cultural differences can best be described as a complex, interactive model. A genetic mechanism is hypothetically responsible for a given base rate of 70% right-handedness (Annett, 1978) at conception. As the population matures, certain environmental constraints in the form of social pressure to conform (Dawson, 1977) may diminish the expression of left-handedness to the 10% usually reported. On the other hand, when paired with a permissive socio-cultural climate, the overall incidence of left- or ambi-handed behavior may be greater than other theories have initially assumed.

HANDEDNESS IN THE NORTH AMERICAN INDIAN

The formulation of the hypothesis that North American Indians differed in their handedness behavior began with anecdotal evidence from a clinical population. When Northwest Coast Indians were referred for neuropsychological assessment, certain differences were noted in their lateral behavior which were unrelated to the side of lesion. On the Harris Test of Lateral Dominance, these patients were less strongly lateralized on the handedness items. Mixed hand use as opposed to the expected consistent right hand use was

more often the rule. On motor performance tests which included the Purdue pegboard and finger tapping, the difference between right and left hand performance was also noteably less than expected. Speculation as to the reason for these differences led to an investigation of the types of tasks requiring hand use in Northwest Coast North American Indian culture. In talking with Indian elders and observing the daily activities of such a culture, it was evident that many of these activities required the simultaneous cooperative use of both hands. Such tasks as clam digging, berry picking, household chores, hauling fish nets and steering boats were dependent on strength and manipulative ability in both hands. Tasks such as writing which required the practice and refinement of one hand were not frequently performed in such a culture. Downing, Ollila and Oliver's (1975) cross-cultural study on the concepts of reading and writing also supported this observation. Downing et al. (1975) reported that their sample of Canadian Indian children attending kindergarten were not as ready to learn to write as a comparable non-Indian sample. The reasons suggested for this difference included the concern that "the Indian children came from a culture with no tradition of written language" (p. 313). Thus, socio-cultural differences may exist with regard to unimanual hand use in the North American Indian population.

Surprisingly, handedness behavior has not yet been directly investigated in any North American Indian societies. Such investigation may ultimately prove useful in identifying socio-cultural variables which influence the development of proficiency and preference. Several indirect measures were derived from the arm bones of retrieved North American Indian skeletons (Smith, 1925; Jolicoeur, 1963). This involved the measurement of the right and left ulna or 'ulna plus' (the ulna plus the hand to the middle knuckle). The results of these studies, however, can only be used to infer the genetic base rates of handedness and not the actual handedness behavior because the effect of cultural and environmental determinants cannot be evaluated by this method.

An investigation of the early literature which described Indian culture and customs was also undertaken in an attempt to find out the kinds of attitudes which were held regarding hand use. Of the few references to the right hand, the first appeared in archival documentation in 1880. The right paws of animals were placed on the right hands of babies to give them special traits (racoon paw - industrious; bear paw - hardworker; squirrel paw - quick, agile; Codere, 1966). Because this documentation occurred only after the first Caucasian contact, it is possible that such characteristics

were incorporated into the lore because of educational and social pressure to be like the Whiteman. This pressure was a result of the Residential movement which was imposed upon many North American Indian communities by well-meaning missionary groups from England. It involved the establishment of a Christian Residential school in each major area of conquest (territory taken over by the church). The main thrust of this movement occurred between 1890 and 1930 (Levine, Note 2). The majority of the Indian children from age 4 to 5 were removed from their families and housed in these Residential schools so that they could have the 'benefit' of proper religious and moral training and learn to speak and write in English. The purpose of residentialism was to strongly suppress the pagan aspects of Indian culture. Potlatching was legislated against. Speaking in the Indian language, while not illegal, was severly punished in the Residential schools (Radin, 1927) and discouraged in the villages. The handedness behavior of Indians also became subject to reform during this time. The use of the left hand for writing was physically discouraged. Elders recall being cut across the knuckles with the metal edge of a ruler for left hand use in school, having the left hand bandaged or being forced to write hundreds of lines with the right hand (Henderson, Note 3). Today, left-handedness is tolerated and ambi-handedness is encouraged and valued by carvers (Hunt, Note 4; Paul, Note 5).

Because the literature concerning handedness behavior in the North American Indian was so limited, more evidence supporting such a cross-cultural difference in handedness was necessary before formulating a testable hypothesis. One way to obtain this evidence was to undertake a study of the Native artforms which depicted hand use. Such an investigation was devised on the basis of other similar studies (Coren and Porac, 1977; Dennis, 1958; Parello, 1970).

ART EFFECTS: THE TOTEM POLE STUDY

Coren and Porac (1977), in their historical study of tool use, based on unimanual tasks portrayed in works of art, reported that the percentage of right-handers had not changed over Five Millenia nor across cultures.

On the assumption that "manifestations of lateral preference in works of art could serve as a record of handedness patterns within the culture that produced them" (p.631), European, Asian, African and American art depicting unimanual tool use was examined over a 5,000 year period. 92.6% of the works depicted right hand use and there were no clear differences found between the various cultural subgroupings.

In such a study, the assumptions that underlay the sampling should be questioned. First, did the artists represent handedness as it occurred in nature and secondly, did all cultures, during the time sampled, produce artwork which was suitable for inclusion in this study? The first assumption provided a basis for such a study. However, one must consider that many civilizations both B.C. and A.D. may not have had suitable artforms; i.e., Hopi and Navajo Indians produced complex geometric designs but not human figures while Mayans produced human figures only with regard to religious events. Some may not have had artforms at all, preferring to pass tradition and history along by word of mouth. These societies, while certainly complex in their organization and culture, would not be represented in such a sample and are less likely to have had a specialized hand for this very reason.

A curious, intrinsic feature of most Northwest Coast Indian art is the concern for symmetry resulting in enantiomorphic representation. Very few tribes deviate from this style. Only the Kwakiutl and the Tagish Indians produced asymmetric artwork which depicted independent unilateral handedness. This artwork was found in carved totem and house poles. (see Figures 1, 2 and 3).

Figure 1: LEFT HAND USE ON THE TALLEST TOTEM POLE AT ALERT BAY, B.C.

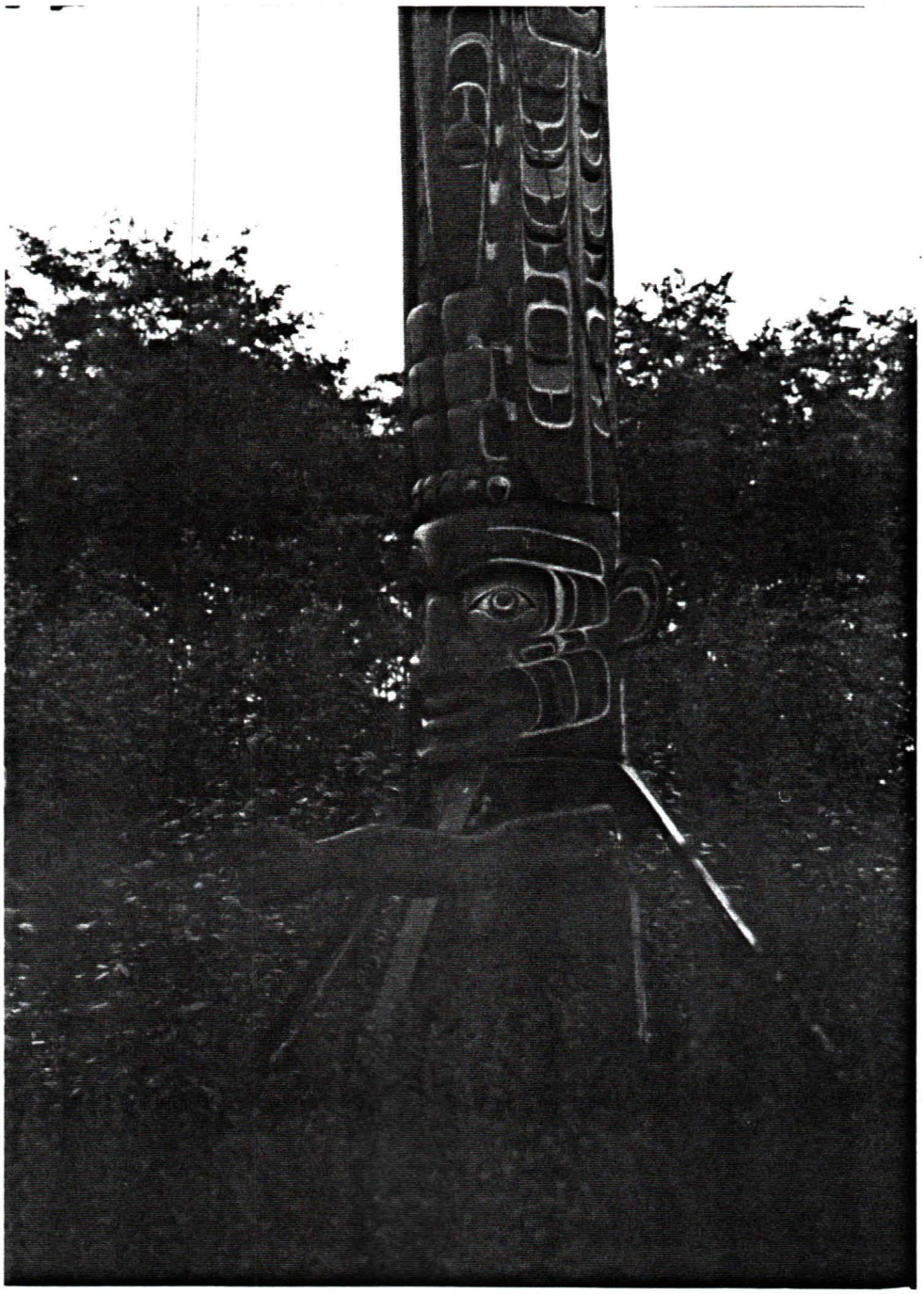


Figure 2: LEFT HAND USE ON GRAVE MARKERS AT CAPE MUDGE

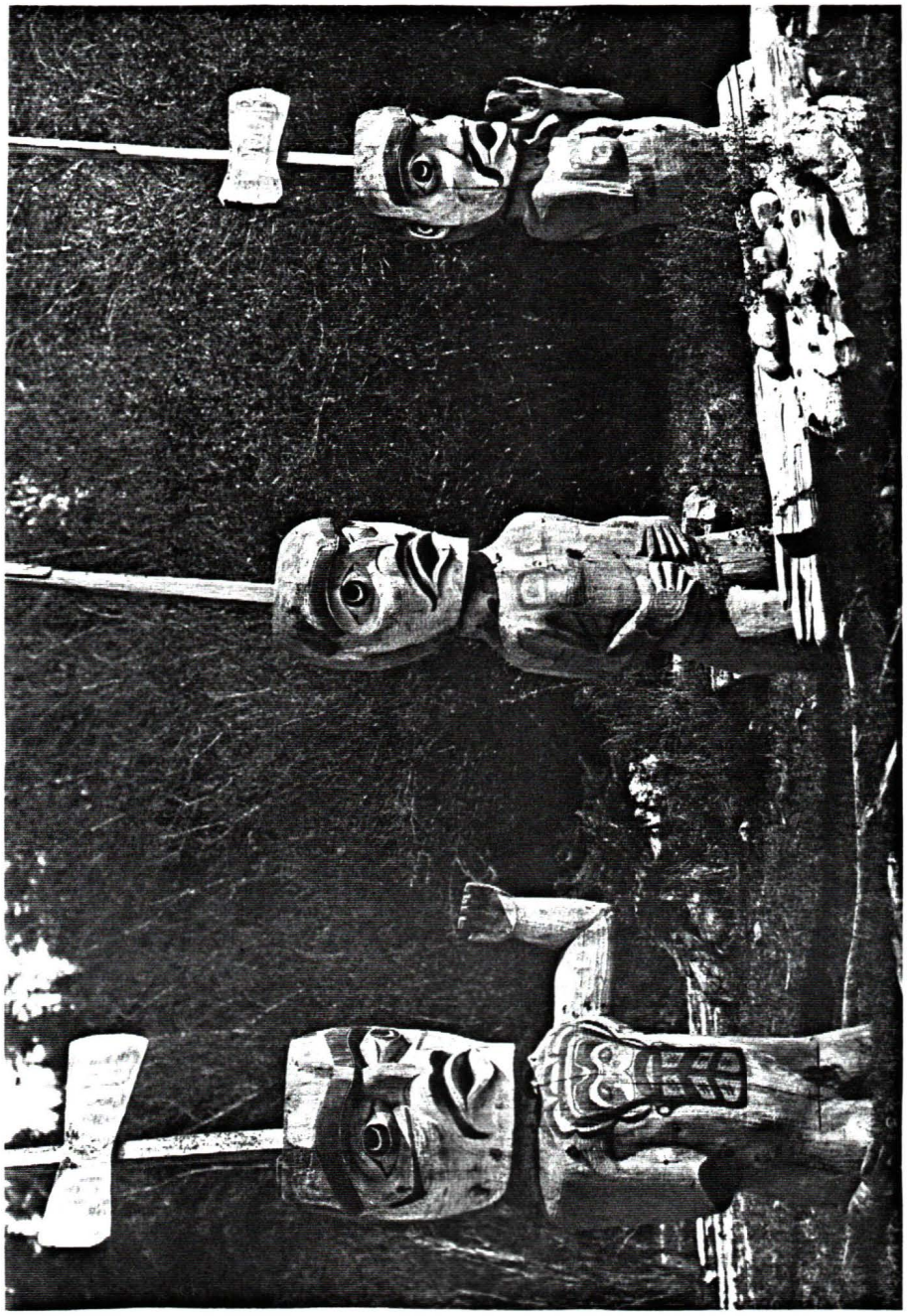
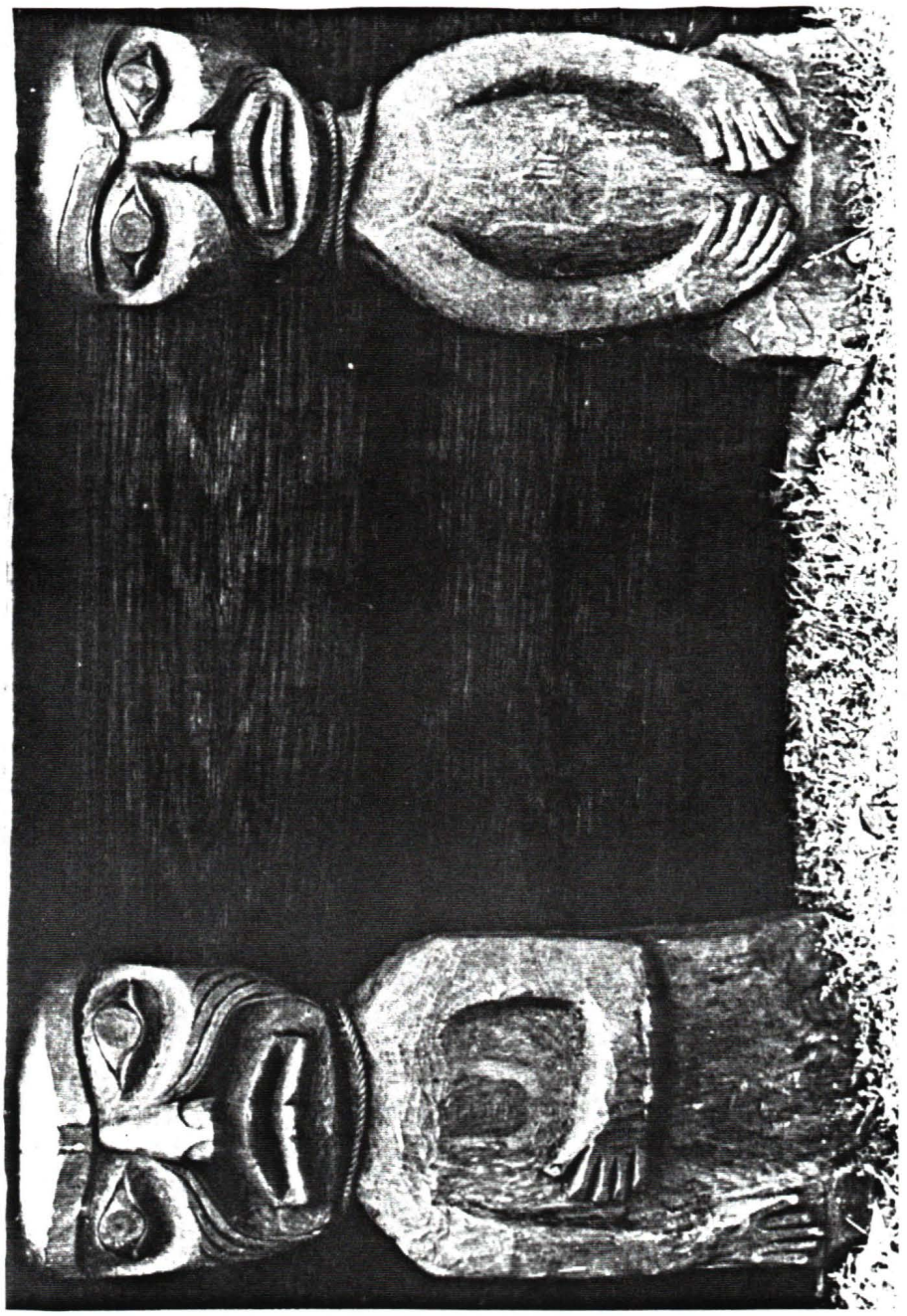


Figure 3: LEFT HAND USE ON BOX SUPPORTING GIRL TO BE MARRIED



Contemporary Kwakiutl and Nootka carvers report that the placement of hands, arms or items on poles is solely a decision made by the carver. However, this placement may represent handedness as it occurred in the culture because the artist was likely to have reproduced the characteristics of his environment as they actually occurred. When a pole is consigned, however, only the figures to be used are specified and the artistic rendering is up to the carver's discretion. Left-handed carvers find it easier to work on the left side of the pole and include more detail there and vice versa for right-handed carvers (Hunt, Note 6). Therefore, there may also be a functional reason for the greater incidence of left-sided items in Indian artwork, if a greater percentage of the carving population are left-handed.

Using a design similar to Coren and Porac's (1977) study, the incidence of unimanual independent handedness in the Kwakiutl totem and house poles was examined (Marrion and Rosenblood, 1981). British Columbia Provincial Museum photographs, from the Ethnology collection of the Kwakiutl, ranging from 1840 to 1950, of all standing poles within the Kwakiutl tribal boundaries (as defined by Franz Boas and the Museum) were selected. Only those poles with clear evidence of independent hand use (hand holding an object) were

counted by two independent judges. In the Kwakiutl sample, 55 % right hand use was recorded. Coren (Note 7) argued that holding behavior occurs in the non-dominant hand. If so, this rationale would reverse the figures resulting in 45 % right hand use.

If the Kwakiutl had no strong preference for hand use, as hypothesized, then this should be reflected by the obtained artwork estimates. Consequently, the expected incidence of either right or left hand use should be close to 50% which is the average number of times either the right or left hand would be chosen to perform a certain task, if no preference existed. The obtained incidences for right hand preference, whether taken as 55% (actual occurrence on the totem poles) or .45% (Coren's 1981 modification), do not differ from chance, $z = -.38$, n.s. and, therefore, may indicate that no strong hand preference existed. As well, out of 98 poles, 67 (68.37%) were found to exhibit bimanual, cooperative hand use. If this artwork was representative of the actual handedness behavior in the Indian culture, it supports Brinton's (1896) and Huheey's (1977) position that Indian and earlier cultures may indeed have been less right-handed, or ambi- handed to a greater degree.

As the incidence of right hand use (55%) in the totem pole study also differed significantly from other artform studies of hand use (93%), the hypotheses concerning potential handedness differences in the North American Indian population were deemed feasible. The Kwakiutl, because they were among the few available North American Indian populations who depicted handedness in their artforms, were selected to investigate the hypothesis that cultural differences in North American Indian populations may contribute to a greater incidence of left- or ambi-handedness. Also, the Kwakiutl resided next to Caucasians who could be sampled as a comparison control group. Since both cultures participated in the same school systems, the differential effects of socio-cultural pressure in the form of Caucasian school requirements on handedness behavior, could be evaluated across the two cultures.

RATIONALE FOR EXPECTING DIFFERENCES IN HANDEDNESS PATTERNS

The Kwakiutl socio-cultural demands for hand use may be less specialized in their nature than Caucasian demands as many of their tasks historically have required the simultaneous cooperative use of both hands. Caucasians have been required to write (and become literate) for at least 400 years (Gelb, 1963) in America and for several millenia

in Europe, while the Kwakiutl and other North American Indians historically had no written graphology. Thus, the majority of Kwakiutl people may not have been subject to the same degree of social pressure to develop right hand use as Caucasians. When handedness is evaluated across age groups by culture, the effect of such socio-cultural pressure on Kwakiutl handedness may be apparent.

Early, unstructured, permissive cultures (Dawson, 1977) such as the isolated hunting societies of some North American Indians may demonstrate less right-handedness. Many of their daily tasks are also bimanual and require the cooperative use of both hands. Boas (1921) lists some 1,500 tasks requiring bimanual cooperation in the Kwakiutl culture. This bimanual hand use may preclude the development of strong or consistent right hand use. Strict, agricultural people may engage in a greater number or to a greater degree (especially for record keeping) in unimanual tasks. Thus, they may be subject to social pressure for hand specialization at an earlier age for specific types of movements such as recording information in the written expression of language. North American Indians, because of less social pressure to conform, may have a greater percentage of left- or ambi- handed members.

Archaeological findings in Europe, North America and Australia indicated that tools were made by left- or ambi-handed craftsmen in a greater percentage than now exist, that more tools were made for use with the left hand and that early artists who drew pictures on cave walls were left-handed to a greater degree.

Cross-cultural studies demonstrated that considerable variance existed across cultures with regard to lateral behaviors including handedness. Cultural dimensions appear to influence lateral behavior (Dawson, 1977) as permissive hunting societies (like those descended from the Aboriginal tribes) have a higher incidence of left-handedness while stricter, agricultural societies have a low incidence.

As well, cultural expectations and demands may influence the final expression of handedness (Gesell and Ames, 1947). An age effect of a rightward shift for handedness is supported by the Porac et al. (1980) summary of studies published over the last 90 years.

An indirect method of determining handedness in North American Indian populations, the study of Kwakiutl totem poles (Marrion and Rosenblood, 1981), revealed 55 % right hand use. A similar study completed by Coren and Porac (1977), over 5,000 years of artwork differed significantly and demonstrated 92.6% right hand use: $z = -9.29$; $p < .001$.

In summary, several lines of indirect evidence including handedness depicted in artforms, anecdotal clinical evidence, reported attitudes and types of tasks suggest that North American Indians may differ in their handedness behavior. The basis for such differences may well be found in a multifactorial model which encompasses genetic, developmental and social pressure factors.

PURPOSE OF THE PRESENT INVESTIGATION

The purpose of the present investigation is to document and explore, in a descriptive fashion, the handedness behavior (as measured by self-report of preference and tested proficiency) in the Kwakiutl Northwest Coast Indian culture that currently resides alongside the Caucasian population at the Northeastern end of Vancouver Island, British Columbia. Distributional and proportional comparisons between the Kwakiutl and adjacent Caucasian groups when age, sex, school environment and geographic location are held constant are expected to support a multifactorial theory of socio-cultural difference and genetic interaction.

Two types of effects will be explored in this preliminary study. They are the handedness distributions and proportions across the two populations as measured by

reported hand use, hand preference and tested hand proficiency. These distributions and proportions will also be assessed across three age levels (age 4 - 6, 10 - 12, and adults).

The percentage of left- and ambi- handed members is expected to be significantly greater in the Kwakiutl sample. The Kwakiutl are expected to demonstrate less consistent right hand use and preference as well as a smaller performance difference between their right and left hands on a proficiency test than the comparative Caucasian sample.

KWAKIUTLS AND CAUCASIANS: HANDEDNESS COMPARISONS

CONTROL MEASURES

Researchers interested in hand preference and proficiency in special populations traditionally have not included any control or comparison groups nor reported the levels of significance between their samples and those obtained by others. This may reflect the level of investigation with regard to cross-cultural differences in handedness since preliminary research simply suggests that differences might exist. At this point, however, with the establishment of variation between cultures (from 86.0% to 99.8%), it is an important next step. Establishing a range of expectancy of the occurrence of right- and left-handedness on large, homogeneous populations such as North American or European Caucasians provides a comparative base rate for culturally different or subcultural populations. The inclusion of a control group (to minimize environmental bias, for example) allows one to comprehend more fully the underlying factors contributing to socio-cultural or genetic differences in the handedness distributions across cultures. If the control population differs from the base rate in the

general population, one can assume either that some extraneous factor is influencing that sector and may well also be influencing the population of interest or that some administrative bias is influencing the responses obtained from both populations. If no control population is used (matched for gender, age, geographical area and socio-economic status), the interpretation of a difference between the population in question and the base rate is problematic.

The present study is unique in several respects. The Kwakiutl and other North American Indians have not yet been directly investigated with regard to handedness behavior. In fact, most of the studies reviewed are only tangentially related to cross-cultural hypotheses. Consequently, the measurement instruments best suited to evaluate such behaviors across cultures are not yet known. Therefore, in this initial investigation, the Kwakiutl sample will be compared against a Caucasian sample and its expected distributions on several measures.

Another major reason for using a control group in this design is the restricted sample size of the Kwakiutl population. The sample gathered represents approximately 10 % of the total population but a much greater percent at the younger age levels. According to the Band lists issued by the Federal Government (1981) which included the children on

the Kwakiutl Reservations, there were 80 children between the ages of 4 to 6 and 143 between the ages of 10 to 12 in the major areas sampled in the present study (Cape Mudge, Campbell River and Alert Bay). Of these, 60 were included in both the age 4 to 6 group and the age 10 to 12 group. Most studies of hand use, preference and proficiency often have a sample size of several thousand (Porac and Coren, 1981), and in this group, such a sample was not possible. A control group was also used as an attempt to mediate administrative bias due to measurement technique or to bias due to a general geographic, environmental factor which may have influenced the handedness incidence in the target population. When direct comparisons are made between two groups on the same measures, administered by the same examiner under the same conditions the conclusions drawn are more meaningful.

The delineation of the age groups across cultures in which developmental differences (due to cultural pressure) were likely to occur was based on the following premises. Gesell and Ames (1947) reported that children were mainly unilateral with regard to hand use by age 4. Preference for writing and other manipulative tasks thereafter becomes more habitual and established especially after they enter school between the ages of 4 to 6. Around the onset of puberty

(age 10 to 12), brain specialization in response to maturational influences appears to be complete and invariant with regard to lateralization of function (Hecaen, 1976; Milner, 1974). At adulthood, a lack of cortical flexibility and plasticity (as demonstrated by the adult brain's response to injury) reflects the high degree of specialization in response to genetic patterns, the environment and maturation. As well, skill in motor performance increases as a function of age and practice and this is noted on various measures of proficiency. This increase should be especially evident at the periods just described. Hand preference and the lateralization of the control of such function is highly correlated and may also increase with age (Witelson, 1977) although this position remains controversial (Levy, 1974).

Finally, in order to control for response bias due to gender, an equal number of males and females were included to reduce the reported tendency for particular patterns of test responses. Bryden (1977) reports that men are more likely to respond in a less extreme manner, resulting in a greater proportion of strongly right-sided women.

SUBJECT SELECTION

All participants resided on the Northeastern end of Vancouver Island, British Columbia, on the West Coast of the mainland of British Columbia directly across from Vancouver Island or on small islands in between these two areas. All Caucasians lived within or adjacent to the Kwakiutl Village areas sampled (outlined in Figures 4 and 5). The data was collected in three separate stages. The age 10 to 12 children were selected first, followed by the age 4 to 6 children and finally the adult group.

The major occupations for adult males of both cultures were logging, fishing and mill work. Females were primarily housekeepers and teachers or worked in the community. The Kwakiutl males were also employed as carvers and dancers. Subjects who reported a history of neurological injury or deficit or who had impaired use of either hand were excluded.

The selection criteria and procedure for the sample varied for the different age groups. The age 4 to 6 children were selected on the basis of parental permission from day care centers, kindergartens, summer play programs and reservations. The school children, age 10 to 12, were selected on the basis of school board, principal and parent

consent and from various elementary schools (Grades 4 to 6) in the Campbell River School District and the Alert Bay School District. As there were greater numbers of Caucasian students available for participation, a selection system was implemented. Consent forms for the Kwakiutl children were counted and an equal number were drawn blind from the available Caucasian pool, matching for gender. This ensured that Caucasians were selected without bias in equal numbers in any given area or school. The adult group was solicited through community centers, North Island College (Campbell River, B.C.), sign-up sheets, school board personnel, by word of mouth and on reservations by form letter, telephone and personal contact. Caucasian adults were obtained in the Campbell River, Quadra Island, Port Hardy, Coal Harbour, and Alert Bay areas. Kwakiutl participants came from the Cape Mudge, Campbell River, Quinsam, Alert Bay, Turnour Island, Coal Harbour, Village Island, Hope Island, Gilford Island, Fort Rupert, Kingcome Inlet and Knight Inlet Reserve areas. Figures 4 and 5 illustrate the geographical areas sampled. The mean age of the Kwakiutl adults was 31.533 and ranged from age 18 to 74, with the majority between 20 and 40. The mean age of the Caucasian adult group was 34.300 and ranged from age 21 to 55. The majority were aged 25 to 40.

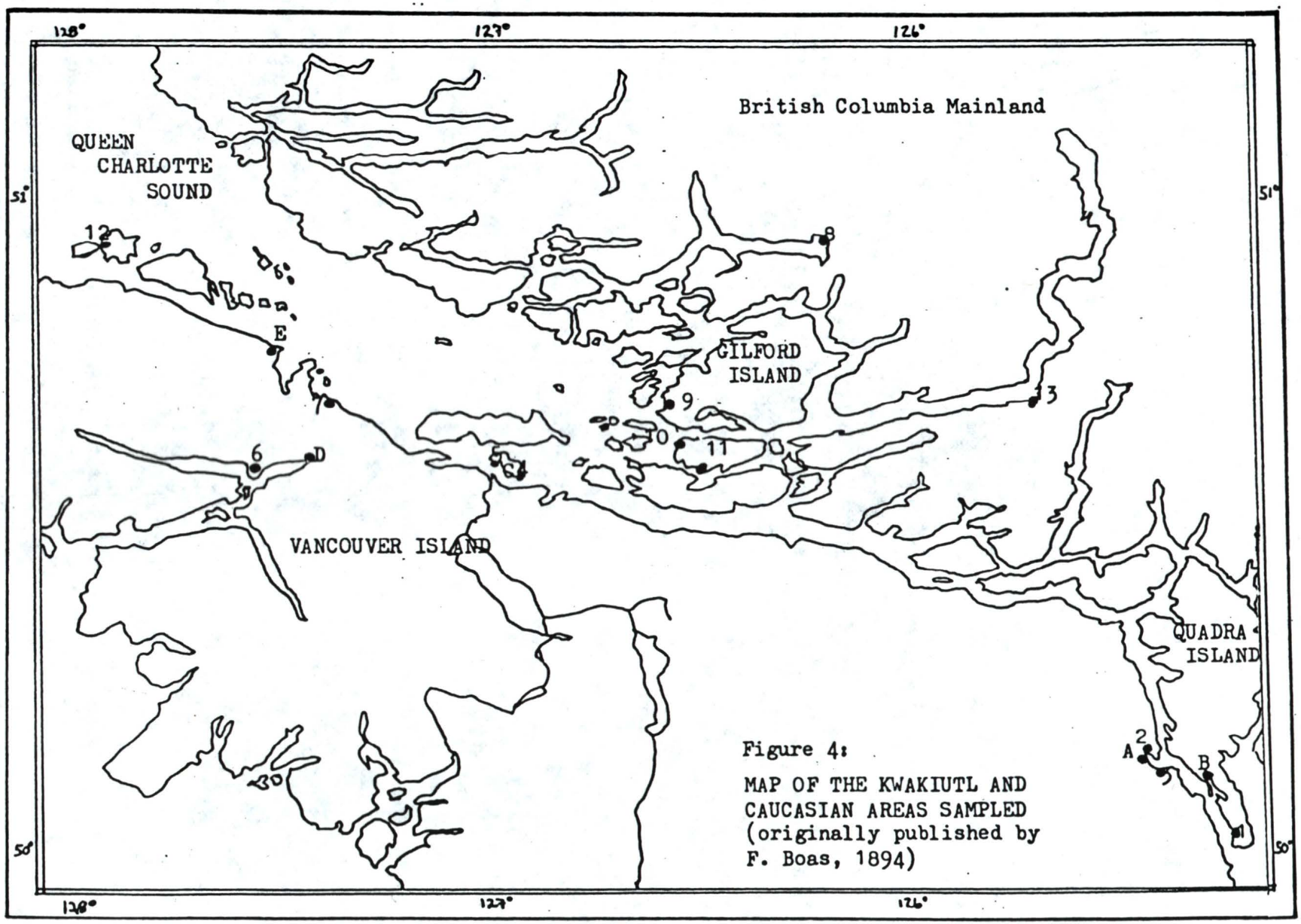


Figure 4:

MAP OF THE KWAKIUTL AND CAUCASIAN AREAS SAMPLED (originally published by F. Boas, 1894)

Figure 5: MAP CODE

KWAKIUTL SAMPLE

	N	BAND	LOCATION
1.	27	Wiwekae	Cape Mudge
2.	63	Wiwekam	Campbell River
3.	28	Kueha	Campbell River
4.	5	Nimpkish	Alert Bay
5.	9	Weetlaliu	Alert Bay
6.	22	Quatsino	Coal Harbour
7.	8	Kwakwelth	Fort Rupert
8.	2	Tsawatenok	Kingcome Inlet
9.	2	Koeksotenok and Huamis	Gilford Island
10.	3	Mamalelekala	Village Island
11.	7	Matilpe and Tlauitsis	Turnour Island
12.	3	Nawiti	Hope Island
13.	1	Tenaktuk and Hwaitlala	Knight Inlet

CAUCASIAN SAMPLE

	N	TOWN
A.	156	Campbell River
B.	21	Quadra Island
C.	0	Alert Bay
D.	2	Coal Harbour
E.	1	Port Hardy

The criterion for inclusion in the Kwakiutl group was determined by the languages spoken by members of the family rather than by skin color, other physical characteristics or lineage. If either the subject, their parents or grandparents had spoken Kwakwalla (the Kwakiutl language), they were included in the sample. This ensured that the socio-cultural background of such subjects was similar and Kwakiutl (virtually no Caucasians are able to speak Kwakwalla with the exception of one or two linguists). Each subject was then verified independently as belonging to the Kwakiutl culture by the inclusion of their name on the Band List (persons formally recognized as belonging on a particular Indian Reservation) or by Kwakiutl Kwakwalla teachers in the school system. The final sample, including both Caucasian and Kwakiutl participants, was 360 individuals with equal numbers of both cultural groups in the different gender and age categories. The 2 x 2 x 3 design included two factors of culture (Kwakiutl and Caucasian), three levels of age (4 to 6, 10 to 12, and adults) and two levels of gender. It is illustrated in Table 3.

TABLE 3

DESIGN SUMMARY

KWAKIUTL (N=180)	AGE 4-6 (N=60)	MALE (N=30) FEMALE (N=30)
	AGE 10-12 (N=60)	MALE (N=30) FEMALE (N=30)
	ADULT (N=60)	MALE (N=30) FEMALE (N=30)
CAUCASIAN (N=180)	AGE 4-6 (N=60)	MALE (N=30) FEMALE (N=30)
	AGE 10-12 (N=60)	MALE (N=30) FEMALE (N=30)
	ADULT (N=60)	MALE (N=30) FEMALE (N=30)

HANDEDNESS MEASURES

A review of the current literature concerning the measurement of hand use, hand preference and hand performance (Coren, Porac and Duncan, 1979; Rackowski, Kalat and Nebes, 1974; Richardson, 1978) revealed the importance of meeting a number of criteria in test selection. In a cross-cultural study these issues are undoubtedly magnified and others come into focus. The selection of measures was therefore guided by a set of criteria deemed appropriate for cross-cultural work.

The indices of hand preference and the hand proficiency test selected for this investigation had high test-retest reliability. In other words, each gave consistent results over a number of different administrations to the same subjects. Thus, if a subject was scored as a right-hander after the first administration, it was highly probable that the same result would be obtained at a second testing. Inter-test agreement was also required. This was a measure of concordancy between instruments where a tested right hand preference or proficiency was stable across all measurement instruments. The self-report questionnaires of hand use and hand preference correlated highly with actual measurements

of proficiency which indicated that they all tapped a similar factor. Satz (Note 8) reported that best hand performance on the Hand Proficiency Test correlated with reported writing hand 99% in right-handers and 97% in left-handers. He obtained these results on some 550 North Americans, age 16 to 60.

Both unimanual (one-handed) and bimanual (two-handed) aspects of handedness were assessed by the questionnaires as these behaviors may have been differentially represented within the two cultures (the Kwakiutl engaging in bimanual activities more frequently than unimanual). Some items pertaining to the interests and common behaviors of both cultures were also included. Furthermore, the tests were easily comprehensible and acceptable to the subjects. The instruments were designed to be given with the same degree of confidence to the three age levels. Also, they were adaptable to the degree that changing the mode of administration (oral, written, or behavioral) would not change the response to the question. Thus, the majority of 10-year-old children who demonstrated writing with their right hands also verbally reported that they wrote with their right hands.

The hand use measure chosen was Yanovitch's Hand Use Inventory (1981) which contained twelve items. The items

had been shown to correlate highly with performance measures such as fingertapping (Satz, Achenbach and Fennell, 1967). The inventory was modified to a three alternative forced choice response mode (left, either or right) from a five choice mode, for several reasons. Bryden (1977) reported a male bias in not responding to extreme right or left choices which resulted in a preponderance of females who were strongly right because they did select the extreme choice. By using a three choice mode, this gender bias was avoided. Secondly, the Hand Preference Inventory chosen also used a three choice mode and, in the interest of consistency for cross-comparison and for reliability measures (four of the hand use items were identical in the two tests), the five choices were reduced to three so that the two instruments were comparable. Both unimanual and bimanual items were represented. Two substitutions were made on the basis of cultural behavioral differences. The items 'shovel' and 'comb' were replaced respectively with 'knife' and 'bingo hand', both activities suggested by a representative of the Kwakiutl (Smith, Note 9). (Bingo hand is the hand used to cover the number called while playing Bingo). It was not known whether either of those questions would have significant impact, as they were not standardized and were not subjected to any rigorous evaluative criterion but were included as a first attempt to minimize cultural bias in the

questionnaire. The questions were easily read and responded to, especially when administered individually and were adaptable across the three age groups. In the age 4 to 6 group, the actual items were presented, in the age 10 to 12 group, the questions were asked orally to each subject and in the adult group, the items were read and responded to by each individual, under the supervision of the administrator. The Hand Use Inventory is illustrated in Appendix A.

The Hand Preference Inventory was derived from a Lateral Preference Inventory (Coren et al., 1979) and included six items that assessed hand preference. Again, it was well standardized, had adequate test-retest reliability (Coren and Porac, 1978) and was also behaviorally validated (Coren and Porac, 1978). It employed the same three choice response format and item administration as the Hand Use Inventory, and was adapted for use at the younger ages in the same manner. The Hand Preference Inventory is illustrated in Appendix B.

The Hand Proficiency Test, designed by Van der Vlugt (1980), required complex, serial, fine motor, eye-hand coordination. It was a unique and relatively unpractised manipulation for each subject, regardless of culture and therefore, provided some protection against a cultural bias. Since the Hand Use Inventory and the Hand Preference

Inventory were standardized and validated against Caucasian populations, they did not necessarily represent the concept of handedness for the Kwakiutl. Preference indicated a choice that might be influenced by a North American Indian expectation of how a Caucasian would answer, especially on items that did not represent the quotidian activities of the Kwakiutl culture. Many authors have reported inconsistency between self-reported preference and actual performance skills, especially in nonright-handers (Porac and Coren, 1981; Provins and Cunliffe, 1972; Satz et al., 1967; Barnsley and Rabinovitch, 1970). The performance task demands (strength versus serial repetition) may interact with preference to give differential classifications. Therefore, performance was a necessary adjunct in the determination of cross-cultural handedness, especially considering the greater reported inconsistency of non-right-handers. Appendix C illustrates the Hand Proficiency Test.

TESTING PROCEDURES

Both the Hand Use Inventory and the Hand Preference Inventory were administered in the same fashion and in the preceding order. The method of administration differed only by age group. For age 4 to 6, the actual items of both tests were presented to the individual alternately with the

right or left hand of the examiner, to a midpoint on the table in front of the child. For example, a small hammer was placed with the right or left hand on the table and the child was asked 'Show me how you use this. Which hand do you hold it in?' The hand used was the hand scored, except in instances where it was picked up with one hand and then transferred to the other for use. The hand that controlled the intended use was then scored. This approach was taken because a pilot study revealed that children of this age often indicated the left hand when queried about their writing hand. When given a pen, they picked it up with the left hand, tried to use it unsuccessfully and then transferred it over to the right hand and promptly used it with ease.

For age 10 to 12, the Examiner read the questions aloud to each individual and marked in the corresponding answers. When the subject had difficulty imagining the use, the actual item was presented as above, and the behavior recorded.

The adults were handed the questionnaires and given a pen with the instructions to 'check off each item as right, if you prefer to use your right hand, either if you use either or don't have a preference and left, if you prefer to use your left hand'. Uncertainties were resolved by asking the

subject to mimic the action. The purpose of the test situation was explained to each adult subject as an attempt to 'find out how you use your hands, which one you prefer to do certain things with and how well you can use each hand'.

The Hand Proficiency Test was administered last. It consisted of an aluminum plate (10cm X 12.5cm) with small holes in a continuous S pattern. The plate was placed overtop a piece of paper and cardboard, in an aluminum three-sided holder. A sharp stylus, held with the thumb, index and middle fingers (much like a pen), was pushed through each hole, puncturing the paper in a continuous fashion. The number of successful punctures within a 30 sec trial was recorded for both hands. The subjects were given an initial untimed practice trial of 5 to 10 holes with each hand. They were then instructed to make as many holes as possible within the time limit. Directionality effects were controlled for by rotating the design 180 degrees each trial. Hand advantage was controlled for by alternating the starting hand on each successive subject and two 30 second trials were given for each hand.

METHODS OF SCORING

The Hand Use Inventory contained 12 preference items and 3 response types - Right, Left or Both/Either. The test was scored by algebraically summing the total responses of each type. A negative value was assigned to all Left hand responses, 0 to all Both/Either responses and a positive value to all Right hand responses. A total score for each individual was derived by adding the negative, neutral and positive values. For example, if the Left total was -4, the Right +5 and Both/Either 2, the resulting score was +1. A score of -12 indicated a strong reported Left hand use and conversely, +12 indicated a strong reported Right hand use.

The Hand Preference Inventory contained 6 hand preference items. These items were scored in the same way as those on the Hand Use Inventory. A score of -6 represented a strong Left hand preference while +6 indicated strong Right hand preference.

The Hand Proficiency Test was scored as follows. A Right and a Left hand score were obtained by finding the average of both trials for each hand. A difference score for each individual was then computed by subtracting the mean score of the left hand from that of the right. This score indicated lateral asymmetry of performance. For

example, a difference score (R - L) of -16 or +16 indicated a high degree of asymmetry while a score of -2 or +2 indicated little difference in performance between the two hands. These difference scores referred to the greater proficiency of one hand over the other. The magnitude of the value indicated the degree of proficiency while the sign indicated its direction.

The scores obtained on each measure were further classified as left-, right- or ambi- handed depending upon where they fell within the distribution of scores on each measure. In the interest of consistency between all three measures, the range for each test was divided into thirds. The upper, positive third represented right-handedness, the middle third was ambi-handedness and the lower, negative third was classified as left-handedness.

CROSS-CULTURAL RESULTS

HANDEDNESS VARIABLES

The major purpose of this investigation was to explore the premise that the Kwakiutl North American Indian culture differs from the general Caucasian population in their handedness behavior. This difference is expected to manifest itself when the two cultures are compared across each of the handedness variables.

Inspection of the descriptive statistics presented in Table 4 reveal the means and standard deviations for the various handedness measures for the two cultural groups. Because hand preference, use and proficiency are not distributed in a Gaussian fashion but appear in most populations as J-shaped functions (Annett, 1972), large standard deviations are expected as the responses vary on a continuum of handedness from one extreme to the other. The mean is also affected by this skewedness or heteroscedascity. Thus, the means and standard error of the means tell one little about the characteristics of the distributions of each culture.

TABLE 4

DESCRIPTIVE STATISTICS BY CULTURE

VARIABLE	CAUCASIAN (N=180)		KWAKIUTL (N=180)	
	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
Hand Use Inventory	7.783	5.369	5.572	6.535
Hand Preference Inventory	4.444	2.939	3.067	3.851
Hand Proficiency, Right Hand	32.436	12.497	28.203	11.432
Hand Proficiency, Left Hand	24.906	9.544	24.844	10.376
Hand Proficiency, (R - L) difference score	7.558	6.044	3.456	4.776

In order to appropriately compare the two samples, given the unusual distribution typically reported for hand preference, use and proficiency measures, a non-parametric test of significance was chosen, namely, the Kolmogorov-Smirnov Two-Sample Test (KS Test). This test, first used by Birkett (1981) for discriminating differences in handedness distributions, compares the characteristics of two independent samples. The test is sensitive to any kind of difference in the distributions from which the two samples are drawn including differences in central tendency, dispersion, scatter or skewness. It compares the two samples by first making a cumulative frequency distribution for each sample of observations and then reporting the largest deviation between the two distributions. The Maximum Absolute Difference (KD) between distributions is the statistic used in the K-S test. In reporting the KD value, a bracketted figure which represents the total number of subjects involved in the distributional comparison will follow the KD notation. Siegel (1951) provides more details of this test. The proportions of left-, ambi- and right-handers, as defined earlier, will also be compared across cultures and age groups. A Z-score, representing a test of independent proportions (Hopkins and Glass, 1978), is the statistic reported for these comparisons.

DISTRIBUTIONAL DIFFERENCES BETWEEN SAMPLES

As writing hand is the most frequently reported criterion for handedness determination in the current literature, the cross-cultural proportional differences between the Kwakiutl and Caucasian samples for writing hand are presented first. Table 5 presents the proportions of right-, left- and ambi- handed writers. These differ significantly across cultures in their incidence and support the hypothesis that a greater number of left- and ambi-handed writers occur in the Kwakiutl sample. A test of independent proportions between the two right hand totals confirms this difference between the two cultures, $z = -4.14$, $p < .001$.

The Hand Use Inventory and Hand Preference Inventory distributions also support the cross-cultural difference hypothesis and are presented in Figures 6 and 7. The distributions are summarized in these figures by applying the formula (R - L/N) to each individual's responses (N = the number of items measured). For example, if an individual responded (on the Hand Use Inventory) right to 12 items, left to 0 and either to 0, his initial score was 12. The score was then 12 divided by 12 which equalled 1. The distributions presented are more manageable and still equally representive. The range was reduced further from 25 points (-12 to 12) in the Hand Use Inventory and 13 points

TABLE 5

DISTRIBUTION OF SIDE OF WRITING HAND BY CULTURE

	RIGHT	LEFT	AMBI-HANDED
KWAKIUTL (N=180)	77.18%	16.82%	6.00%
CAUCASIAN (N=180)	92.78%	6.66%	.56%

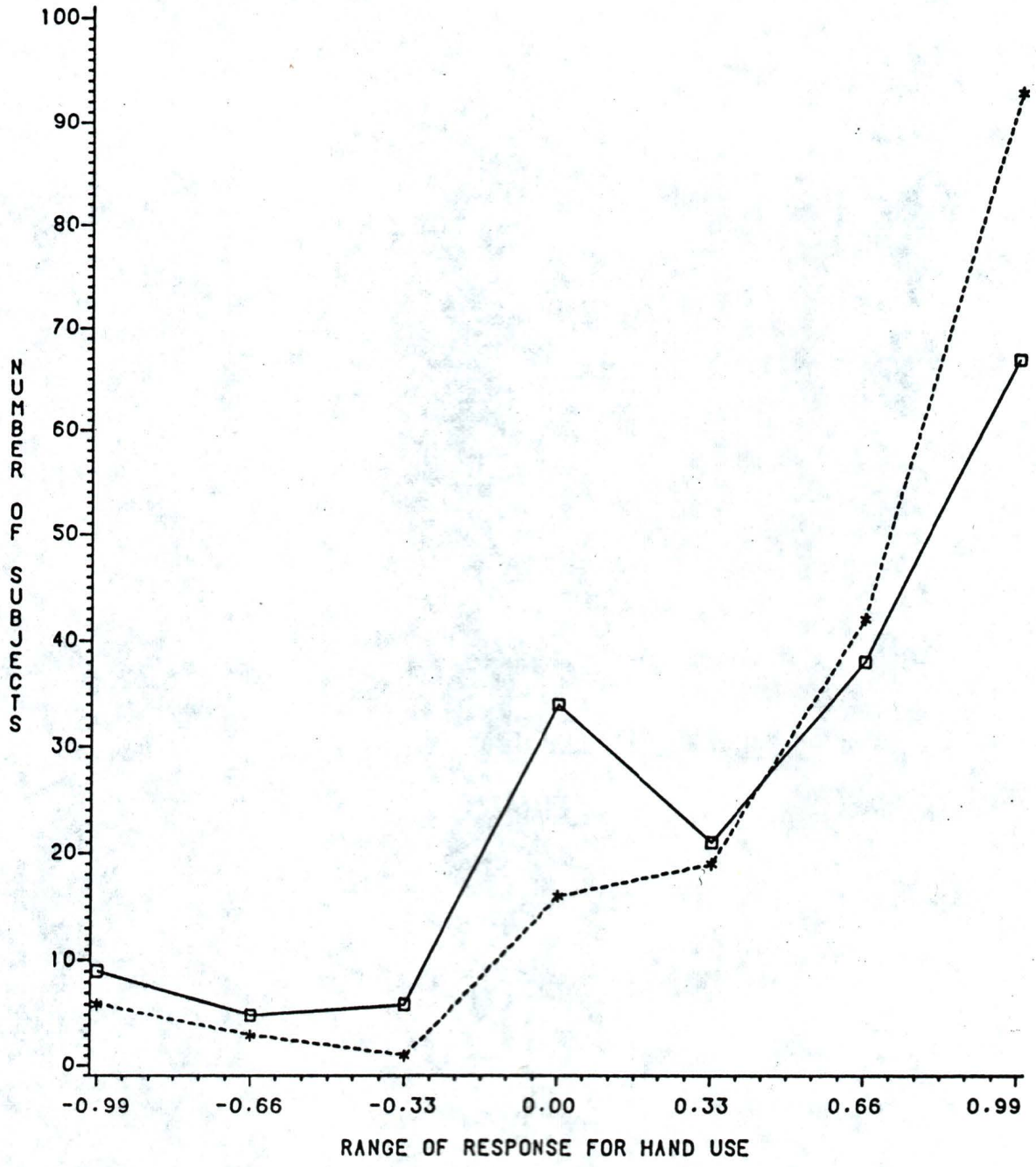
(-6 to 6) in the Hand Preference Inventory to 7 points (-.99, -.66, -.33, 0, +.33, +.66 and +.99) which are consistent between all measuring instruments and simplify the comparison process. The negative values between -.99 and -.33 reflect the left-handed proportion, the values between -.33 and +.33 indicate the ambi-handed proportion and the right-handed proportion is represented by the positive values between +.33 and +.99.

When the proportions of ambi-handed subjects in each culture (-.33 to +.33) are compared on the Hand Use Inventory, a significant difference is found, $\underline{Z} = 2.50$, $\underline{P} < .01$. This difference supports the hypothesis that hand use is less specialized in the Kwakiutl population. On the Hand Preference Inventory, cultural differences are also significant between the proportions of the right-preferent groups, $\underline{Z} = -3.17$, $\underline{P} < .001$, and the ambi-preferent groups, $\underline{Z} = 2.50$, $\underline{P} < .05$.

When the distributions of handedness scores on the Hand Use Inventory, rather than the proportions, are compared, the Kwakiutl distribution indicates significantly less right hand use on the Hand Use Inventory, $\underline{KD}\ (360) = .1889$, $\underline{p} < .01$. The maximum differences are located on the positive side of the distribution and represent less frequent use of the right hand with regard to the test items.

HAND USE INVENTORY DISTRIBUTION

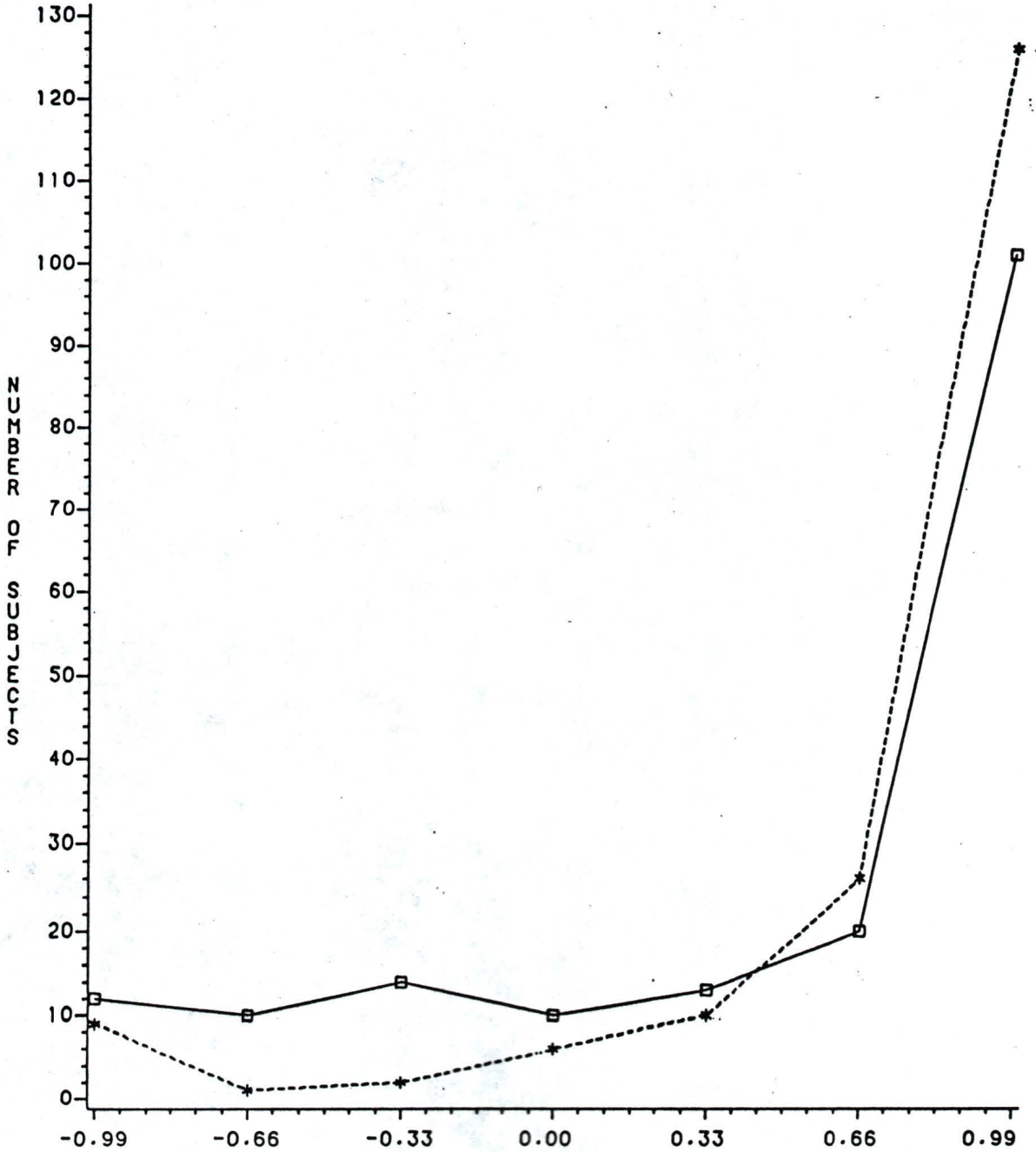
BY CULTURE
(RIGHT-LEFT)/N
FIGURE 6



KWAKIUTL SQUARE
CAUCASIAN STAR

HAND PREFERENCE INVENTORY DISTRIBUTION

BY CULTURE
(RIGHT-LEFT)/N
FIGURE 7



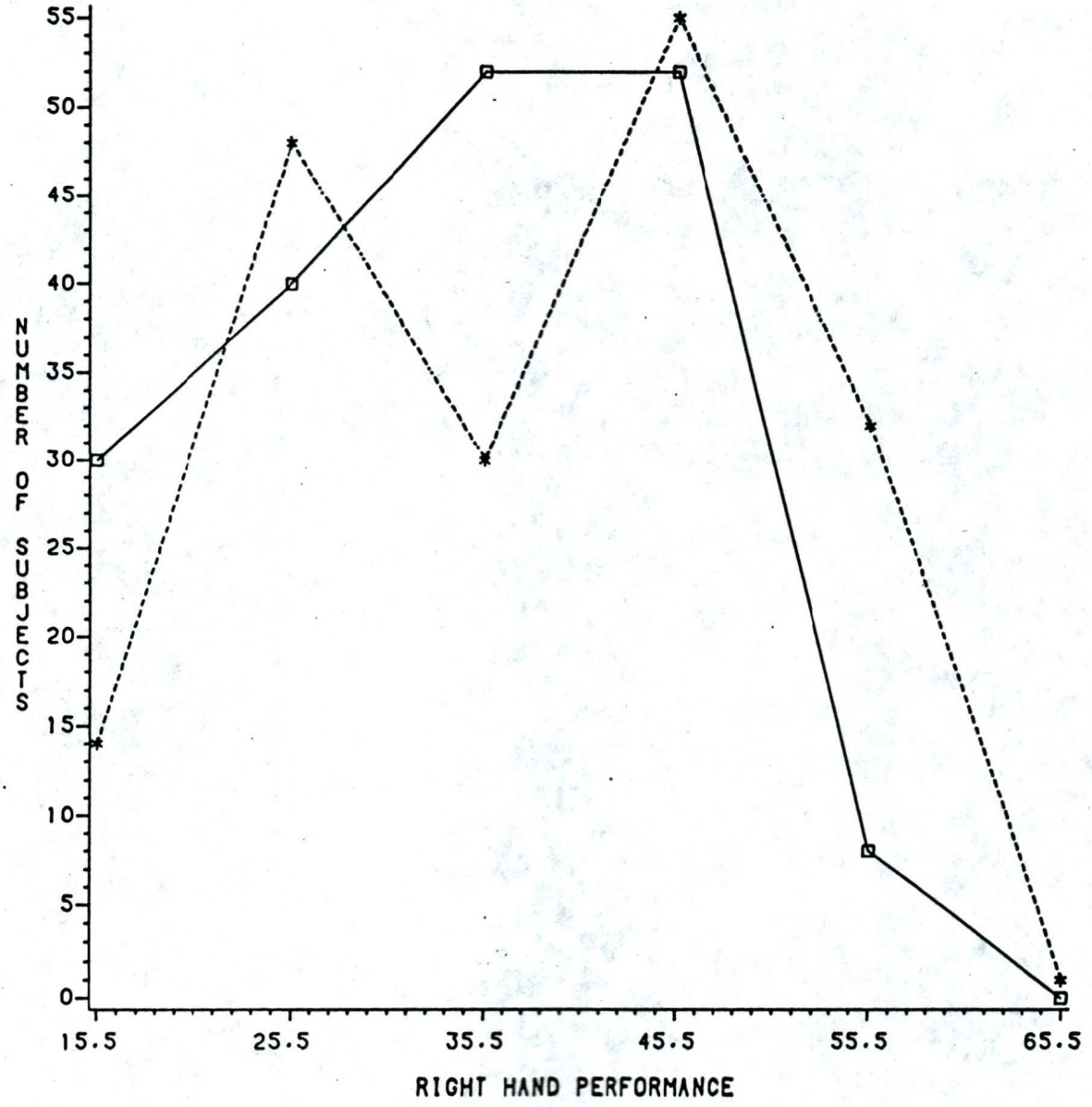
The Kwakiutl distribution on the Hand Preference Inventory is also significantly different from that of the Caucasian sample, KD (360)=.1722, p <.01. The maximum differences occur on the ambi- and right- handed side of the distribution and indicate less preference for right hand use.

The Hand Proficiency Test is a behavioral task which measures actual hand performance. It demonstrates a very interesting difference between the Kwakiutl and the Caucasian distributions. The two groups perform equally well with their left hands and there is no significant difference between the two distributions, KD (360)=.0556, n.s. on left hand performance. However, the distributions for right hand performance indicate that the Caucasian sample have a distinct right hand advantage on this task. The difference between the two distributions on this variable is significant, KD (360)=.1944, p <.01. The right hand advantage for the Caucasian sample is illustrated in Figure 8 on the right side of the graph. Figure 9 illustrates that both left hand distributions are equal.

As well as the distributional differences between cultures on right hand performance, a test of the means demonstrates similar results. Right hand performance differs by culture, t (358) = 4.73, p <.001, but left hand performance does not, t (358) = .083, n.s.

RIGHT HAND PROFICIENCY

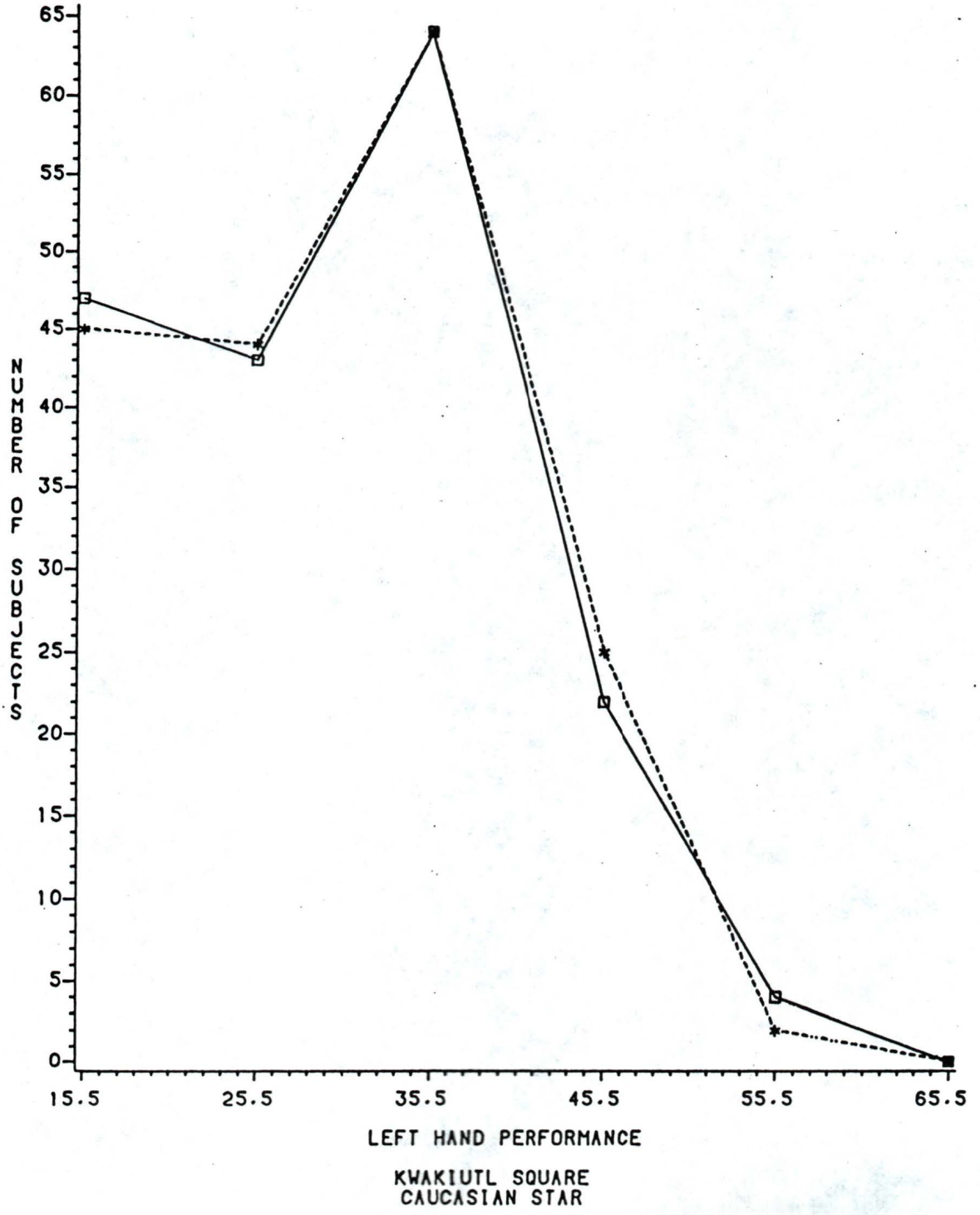
BY CULTURE
FIGURE 8



KWAKIUTL SQUARE
CAUCASIAN STAR

LEFT HAND PROFICIENCY DISTRIBUTION

BY CULTURE
FIGURE 9

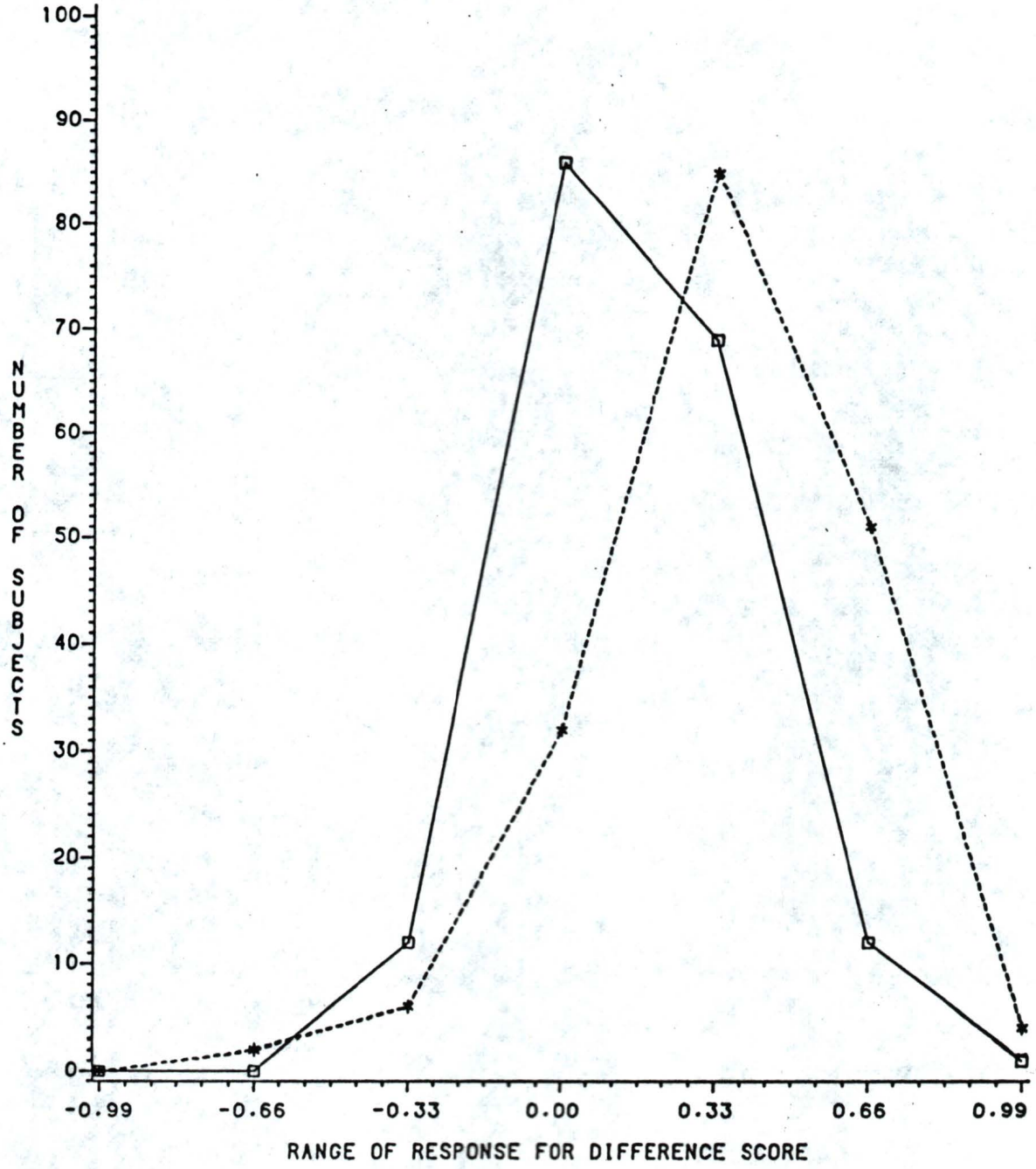


To minimize the effect of increasing skill with increasing age between the two distributions, the difference score (R - L) between the Right and Left hands was used as an index of proficiency. A difference score effectively reduces the total performance range and also represents a measure of lateral proficiency with a negative score of -.99 to -.33 indicating a left hand advantage, a score of -.33 to +.33 reflecting ambi-handedness and a positive score of +.33 to +.99 representing a right hand advantage. Figure 10 presents the difference score distributions across cultures. When these difference scores are scrutinized across cultures, the same pattern again emerges. The Kwakiutl sample are more ambi-handed and consequently tend to demonstrate little proficiency difference between hands when compared to the Caucasian sample, $\underline{KD}$ (360)=.4000, $\underline{p}$ <.001. Most of the Kwakiutl scores are distributed within the -4.5 to 5.0 range while Caucasian scores are shifted to the right and fall within the 4.5 to 15.0 range. When the mean right-hand scores on the Hand Proficiency Test for each of the two cultures are compared, these differences are supported, $\underline{t}$ (358)= 10.077, $\underline{p}$ <.001.

In summary, cross-cultural differences in handedness behavior between the Kwakiutl and the Caucasian populations are found on all three variables which include both self-

HAND PROFICIENCY DIFFERENCE SCORE DISTRIBUTION

BY CULTURE
(RIGHT-LEFT)/N
FIGURE 10



KWAKIUTL SQUARE
CAUCASIAN STAR

report and behavioral measurements. These differences are a result of a significantly greater proportion of left- and ambi- handed members in the Kwakiutl population.

ANALYSIS OF AGE AND CULTURAL DIFFERENCES

The age difference by culture hypotheses, that right hand use, preference and proficiency increases with age but differentially by culture is generally supported by the trends in the data. At times, however, these trends are not significant.

The writing hand distribution by age and culture are presented in Table 6. An interesting difference occurs in the Kwakiutl sample while the Caucasian sample remains relatively unchanged over age.

The Kwakiutl sample, at age 4 to 6, contains the smallest number of right-handed writers. This increases at age 10 to 12 but again drops off at adulthood. This may represent environmental pressure to increase the use of the right hand during the school years in the Kwakiutl sample. A test of independent proportions (see Z-scores in Table 6) reveals significant differences in the proportions of right-handed writers across all age levels by culture. The Caucasian handedness proportions for writing seem to be fixed by age 4 to 6 and remain invariant over age. The

TABLE 6

DISTRIBUTION OF SIDE OF WRITING HAND BY AGE AND CULTURE

AGE	KWAKIUTL (N=60)		CAUCASIAN (N=60)		Z-SCORE
	RIGHT %	LEFT %	RIGHT %	LEFT %	
4 - 6	72	21	93	7	-4.60***
10 - 12	83	14	93	7	-5.86***
ADULT	78	15	92	7	-6.35***

$p < .05$*, $p < .01$**, $p < .001$***.

Kwakiutl proportions appear to be influenced by the school environment as right-handed writing subsequently decreases as they move away from school age. Levy's (1974) and Dawson's (1977) research, among others, implies that people who are inconsistent or mixed in handedness are more amenable to cultural pressure or environmental influence with respect to hand use. According to Levy (1974), the strong pressure exerted by North American parents and teachers in the 1930's to the 1950's was effective in reducing left hand use to as little as 2%. The Kwakiutl sample, which has a smaller number of ambi- and left-handers at age 10 to 12, may be following this pattern during their educational period. The dropoff in the adult sample may also be due to a cohort effect as the data are cross-sectional rather than longitudinal. It is difficult to know whether the adults sampled were subject to greater or lesser degrees of social pressure during their education to use their right hands. Their experience may have differentially biased their handedness behavior but this is unknown.

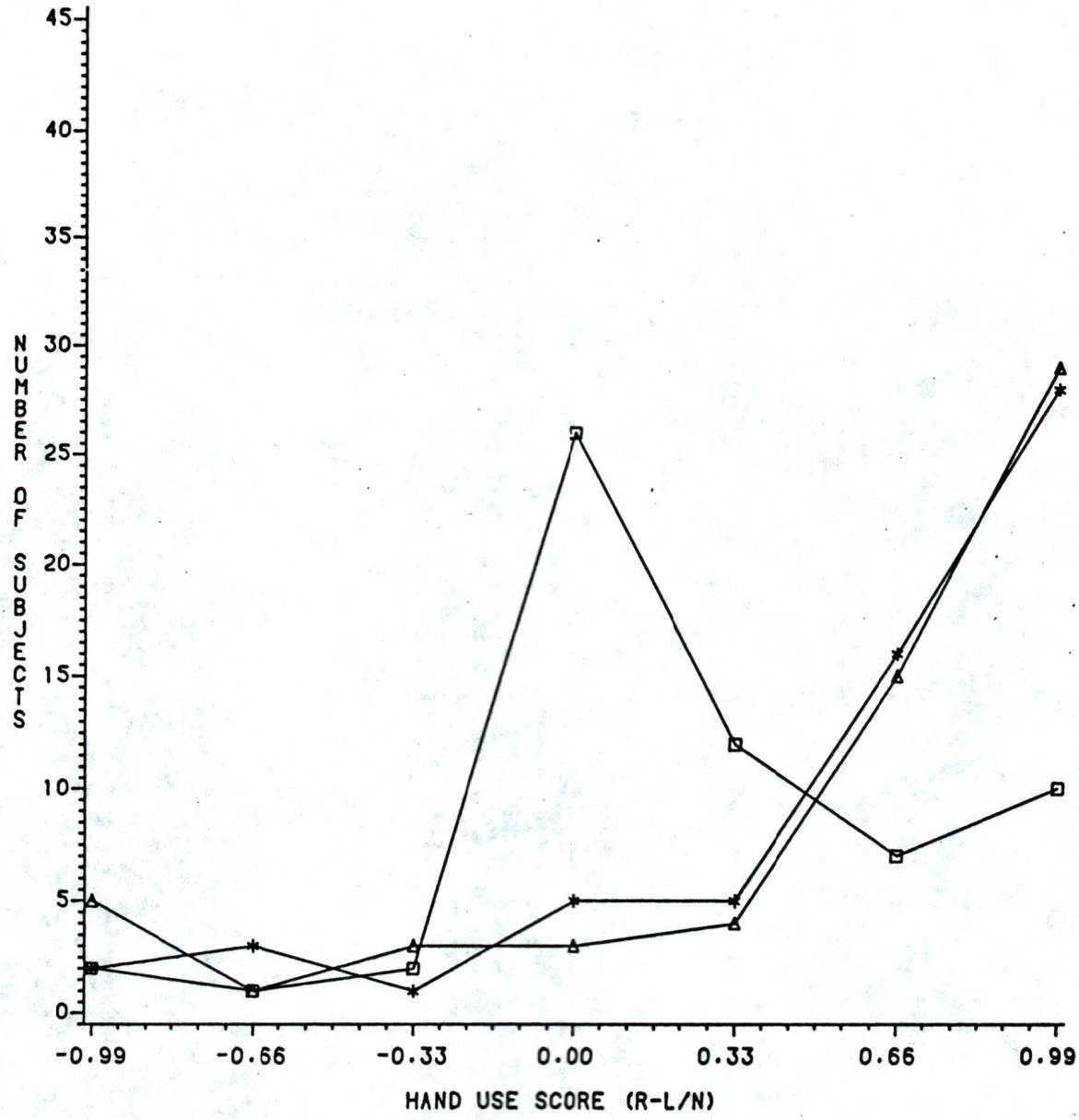
The Hand Use Inventory, when examined by culture at the different age levels, reveals an interesting pattern which is consistent with the writing hand proportions just described. The Kwakiutl age distribution indicates more right hand use in both its age 10 to 12 group, KD

(120)=.4833, p <.001, and its adult group, KD (120)=.4500, p <.001., when compared to its age 4 to 6 group which demonstrates more ambi-handed use. Figure 11 illustrates this initial difference between the youngest Kwakiutl age group and the other two. The Caucasian age distribution also exhibits an early ambiguity with respect to hand use. The distribution of the age 10 to 12 Caucasian group indicates a significant increase in right hand use, KD (120)=.3000, p <.01, over the age 4 to 6 Caucasian group. The adult Caucasian group is also significantly more right-handed, KD (120)=.5000, p <.001, when compared to the age 4 to 6 Caucasian distribution. Figure 12 presents these distributions.

As well as the differential pattern of hand use across the three age age levels within each culture, there is a culture by age interaction. The Kwakiutl and Caucasians both show a trend of increased right hand use over age but the rate at which this occurs differs. The Kwakiutl become more right-handed at each age group but at a slower and less inclusive rate. The results, when viewed at each age level across culture, are more comprehensible. At age 4 to 6, the majority of the Kwakiutl are ambi-handed while most Caucasians use their right hands. At age 10 to 12, the Kwakiutl ambi-handedness is replaced with an increased shift toward right hand use which is surpassed by the right hand

HAND USE INVENTORY DISTRIBUTION

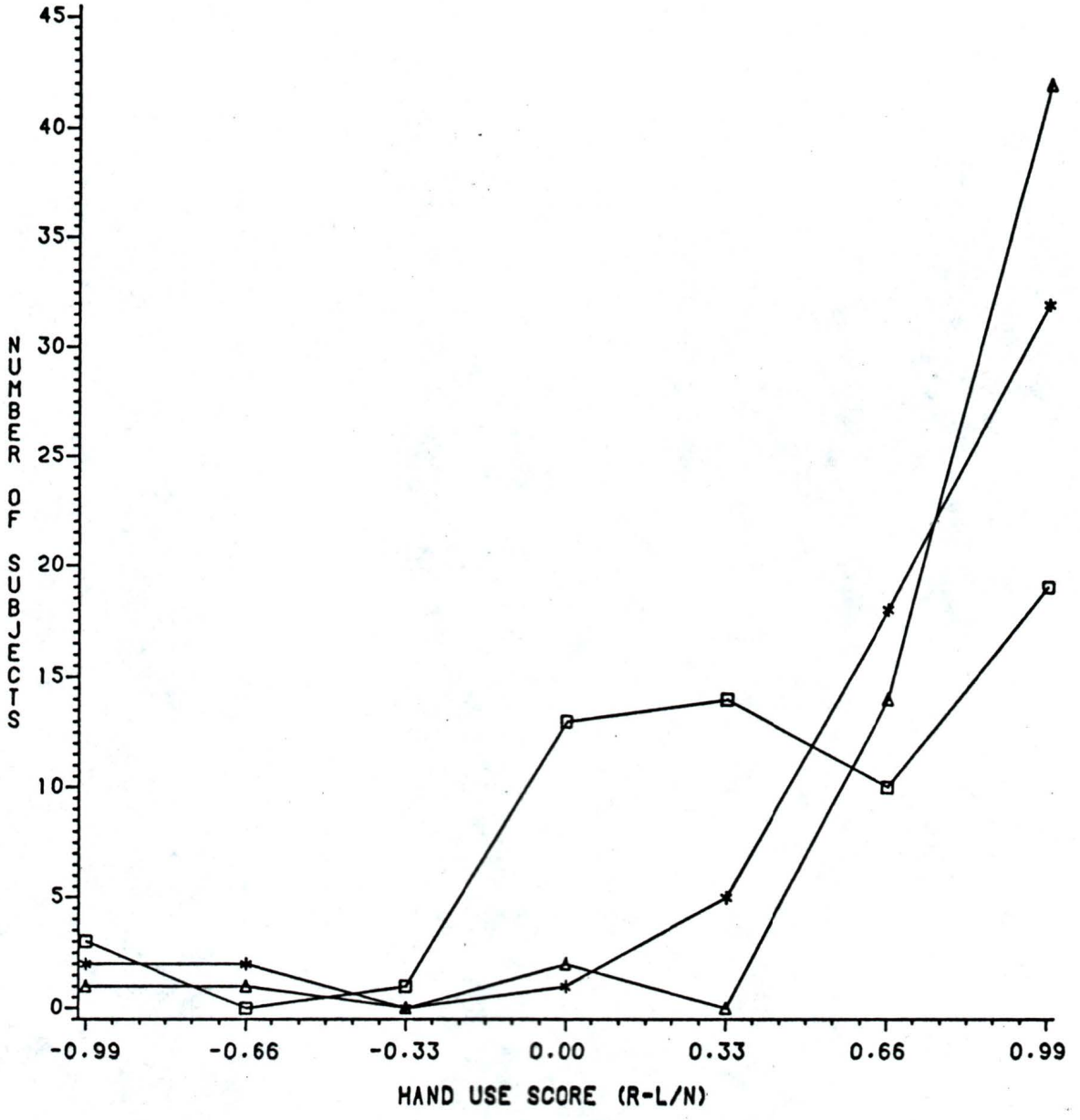
KWAKIUTL BY AGE
FIGURE 11



AGE 4 TO 6=SQUARE
AGE 10 TO 12=STAR
ADULT=TRIANGLE

HAND USE INVENTORY DISTRIBUTION

CAUCASIANS BY AGE
FIGURE 12



AGE 4 TO 6=SQUARE
AGE 10 TO 12=STAR
ADULT=TRIANGLE

use of the Caucasian age 10 to 12 sample. At adulthood, the Kwakiutl distribution remains shifted towards the right but it is still significantly less than that of the Caucasian adult distribution, KD (120)=.2833, p <.05.

When mean differences are examined across the three age levels by culture on the Hand Use Inventory, the pattern is similar to that seen for writing hand where the age 10 to 12 Kwakiutl and Caucasian groups differ least. At age 4 to 6, the Kwakiutl show less right hand use than the age 4 to 6 Caucasians, t (118) = 2.93, p <.01, but at age 10 to 12, demonstrate an increase in right hand use when compared to the age 10 to 12 Caucasians, t (118) = 1.74, n.s. At adulthood, the Kwakiutl again demonstrate a decreased right hand use, t (118) = 4.096, p <.001 when compared to the Caucasian adults.

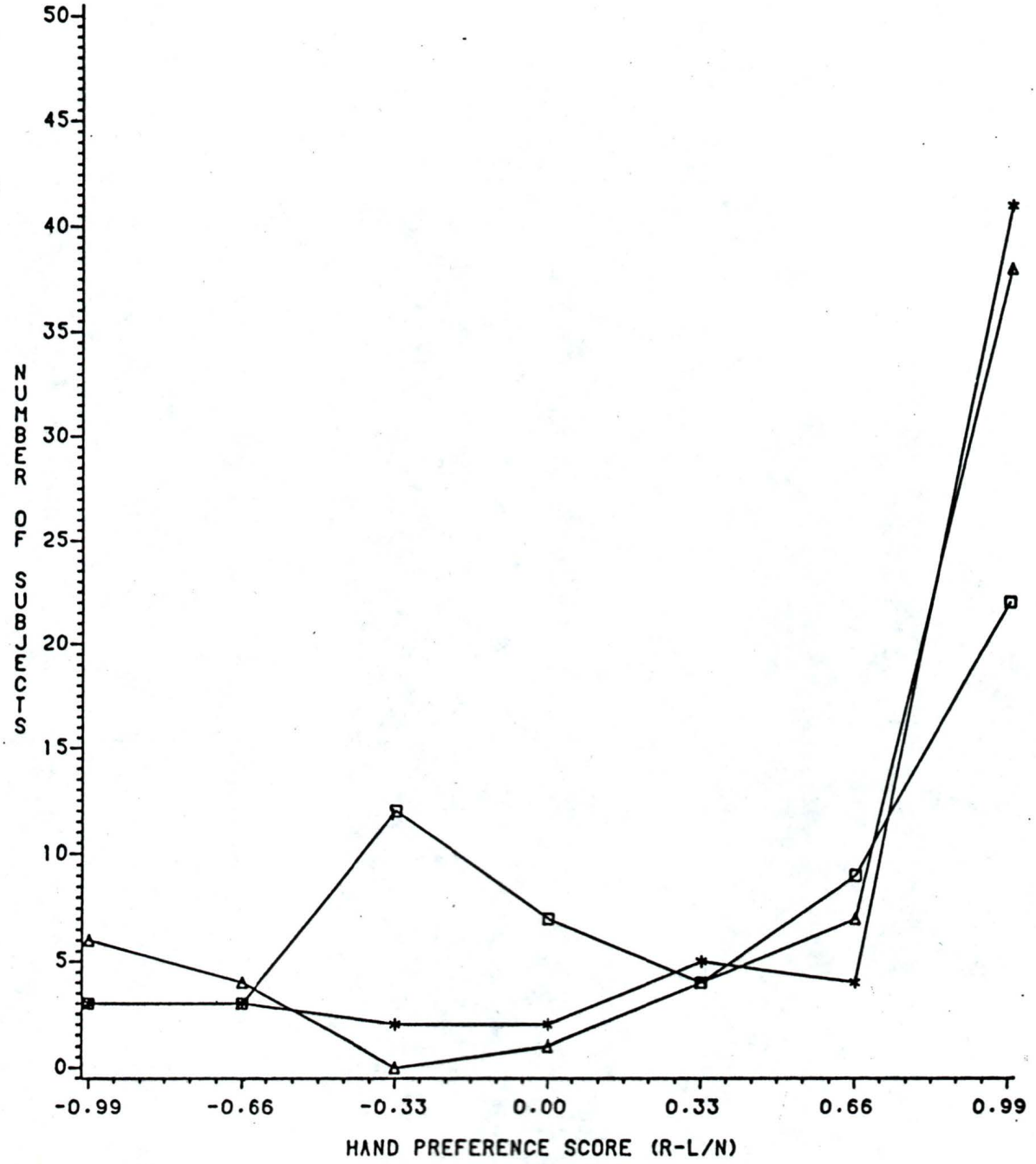
With regard to Hand Preference, the Kwakiutl distribution indicates a right preference for its age 4 to 6 group which increases significantly and stabilizes at its age 10 to 12 group, KD (120)=.3167, p <.01. Figure 13 illustrates the distributions of the three age levels for the Kwakiutl. The Caucasian distribution indicates a similar pattern but at each age level, the number of individuals who demonstrate a strong right hand preference is much higher than in the Kwakiutl sample. The Caucasian sample demonstrates a large significant increase in Right

hand preference between its age 4 to 6 and 10 to 12 groups, KD (120)=.3667, p <.001, but not between its age 10 to 12 and adult groups, KD (120)=.0833, n.s. Figure 14 illustrates the distributions of the three age levels for the Caucasians.

When the distributions of the Hand Preference scores are examined at each age level by culture, the following pattern emerges. At age 4 to 6, the Kwakiutl distribution indicates greater ambi-handed preference and less right-handed preference than the Caucasian age 4 to 6 distribution, KD (120)= .2333, p <.05. At age 10 to 12, the Kwakiutl distribution also indicates more ambi-handed preference and less right-handed preference than the Caucasian distribution, KD (120)=.1500, n.s., but this trend between the two cultures is not significant. The adult Kwakiutl distribution indicates more left-handed preference than the Caucasian adult group, KD (120)=.1833, p <.05. The overall Caucasian trend is a pattern of increasing right hand preference over age. The overall Kwakiutl trend is that of initial ambi-handedness which is replaced by increasing left- or right- handedness. Thus, the majority of the age 4 to 6 Kwakiutl are ambi-handed in their preference. As they age, this ambi-handedness is replaced by either a stronger right- or left- handed preference. Both the populations demonstrate an increase in the strength

HAND PREFERENCE INVENTORY DISTRIBUTION

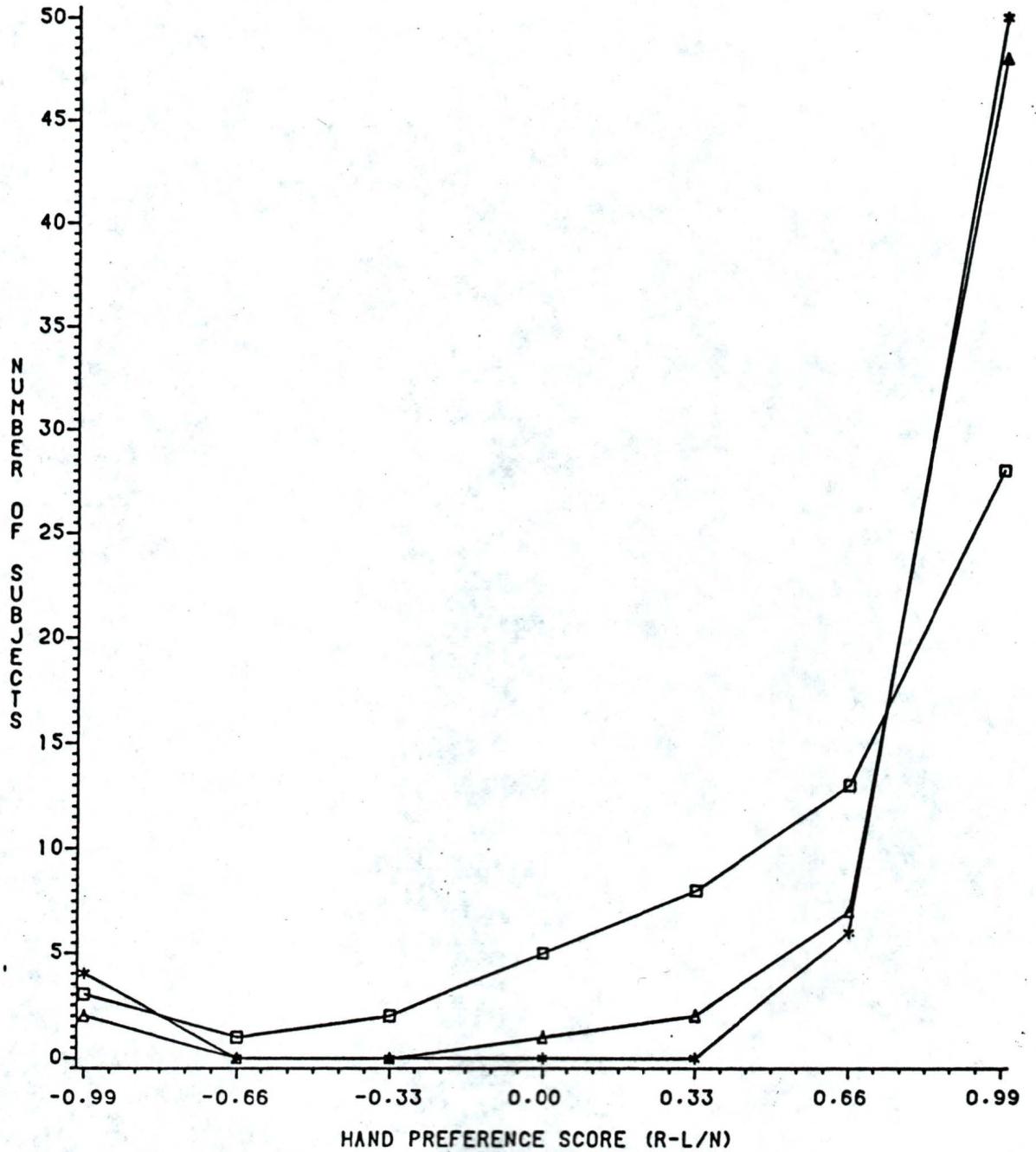
KWAKIUTL BY AGE
FIGURE 13



AGE 4 TO 6=SQUARE
AGE 10 TO 12=STAR
ADULT=TRIANGLE

HAND PREFERENCE INVENTORY DISTRIBUTION

CAUCASIANS BY AGE
FIGURE 14



AGE 4 TO 6=SQUARE
AGE 10 TO 12=STAR
ADULT=TRIANGLE

or consistency of handedness behavior over age but the directions differ. Most of the Caucasian sample become strongly right-handed as do a substantially lower proportion of the Kwakiutl population. In fact, a relatively larger number of Kwakiutl become strongly left-handed, indicating an increase in strength or consistency of handedness over age.

When the means for the Hand Preference scores are examined, cultural differences are significant across all age levels. The age 4 to 6 Kwakiutl are less right preferent than the age 4 to 6 Caucasians, t (118) = 2.24, p <.01. The age 10 to 12 Kwakiutl are also less right preferent than the age 10 to 12 Caucasians, t (118) = 2.239, p <.01. The adult Kwakiutl are the least right preferent, t (118) = 3.90, p <.001, when compared to the Caucasian adults.

The Hand Proficiency Test also demonstrates the unusual distributional pattern in the Kwakiutl sample over age seen in the hand writing distribution. Table 7 presents the hand proficiency distributions by age and culture. The age 4 to 6 Caucasian distribution has a large number of ambi-handers but by age 10 to 12, these become stable and strongly right-handed (92 - 93%). The age 4 to 6 Kwakiutl group are ambi-handed but there is an unexpected right-handed advantage in the age 10 to 12 group of 90%. The

TABLE 7

DISTRIBUTION OF STRENGTH OF HAND PROFICIENCY BY AGE AND CULTURE

AGE	KWAKIUTL (N=60)		CAUCASIAN (N=60)		KD
	RIGHT %	LEFT %	RIGHT %	LEFT %	
4-6	75	20	88	10	.3667***
10-12	90	7	93	7	.5000***
Adult	75	23	92	8	.5333***

MEANS ON HAND PROFICIENCY BY AGE AND CULTURE

	KWAKIUTL (N=60)	CAUCASIAN (N=60)	T-TEST
AGE 4-6			
RIGHT	14.833	17.392	1.28
LEFT	13.493	13.592	.34
(R - L)	1.483	3.817	8.68***
AGE 10-12			
RIGHT	30.908	35.550	6.647***
LEFT	26.525	26.608	.12
(R - L)	4.350	9.008	6.645***
ADULT			
RIGHT	34.575	44.367	10.908***
LEFT	38.867	34.517	-5.848***
(R - L)	4.533	9.850	6.526***

$p < .05$*, $p < .01$**, $p < .001$***.

Kwakiutl adults are slightly less right-handed than the Kwakiutl age 10 to 12. One explanation may be that environmental or functional pressure operates during the school years to increase right hand use and proficiency. The Kwakiutl (and other North American Indian people), on the average, leave the school system and its socio-cultural demand for right hand use at Grade 8 or 9, because of its inadequacy in meeting their needs as a group (More, Note 10). After leaving this environment, they may have reverted towards their original status with regard to hand use and proficiency by the time they were sampled. The Caucasian adults in this sample had usually completed Grade 12 and did not report the same disinterest with writing as some of the Kwakiutl adults.

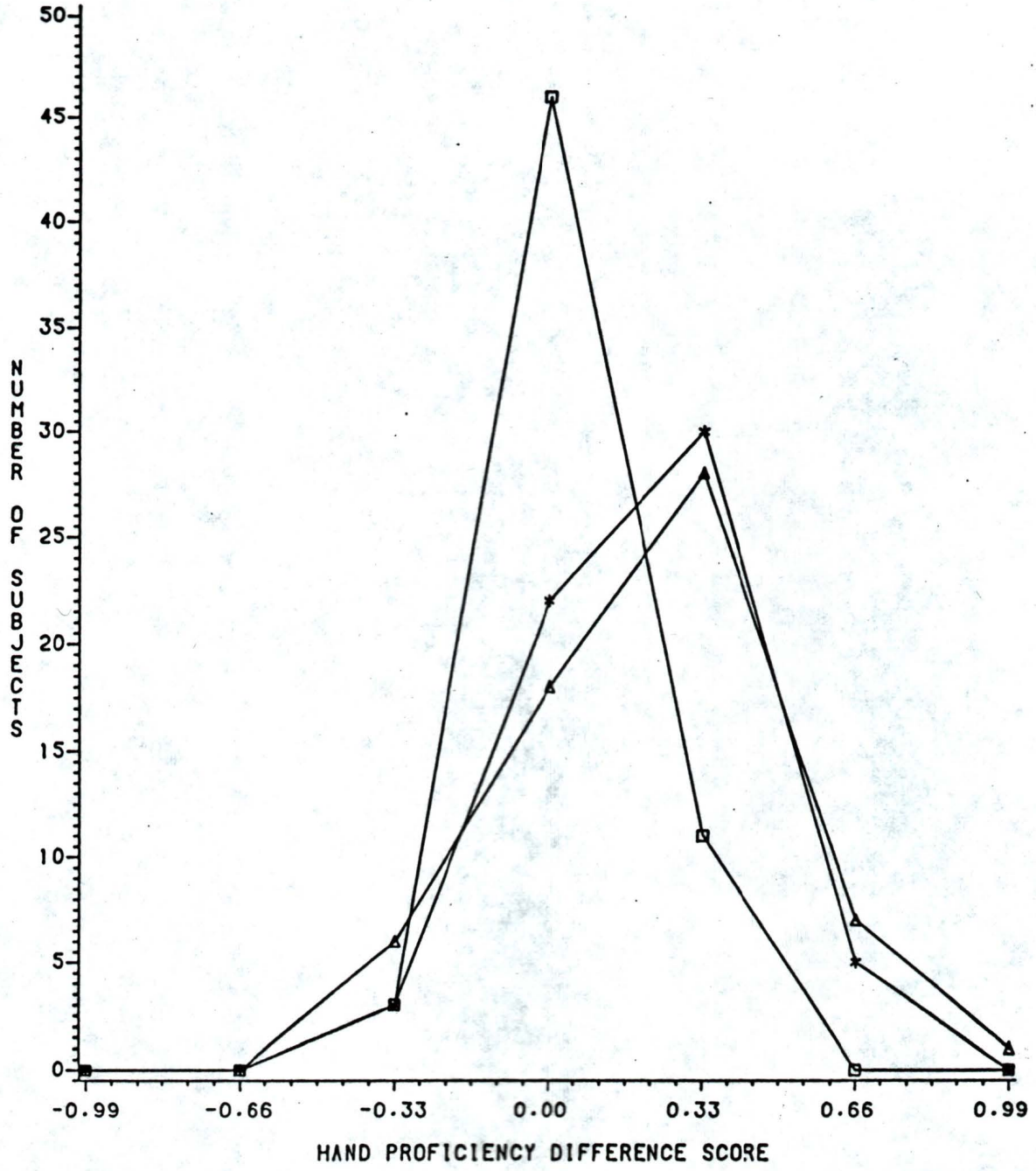
All three age group distributions, when compared across culture, differed significantly on the Hand Proficiency difference score. The age 4 to 6 Kwakiutl and Caucasian groups differed, $\underline{KD}$ (120)=.3667, $\underline{p}$ <.001; the Kwakiutl and Caucasian age 10 to 12 groups differed, $\underline{KD}$ (120)=.5000, $\underline{p}$ <.001; and the Kwakiutl and Caucasian adult groups differed, $\underline{KD}$ (120)=.5333, $\underline{p}$ <.001. Figures 15 and 16 illustrate that distributional differences occur because the Kwakiutl difference scores are consistently smaller and skewed to the left when compared to the Caucasian scores. In fact, the mean difference scores for all three age levels of the

Kwakiutl sample are less than or not significantly greater than the lowest mean Caucasian difference score (which occurs at age 4 to 6). Thus, both the age 10 to 12 and adult Kwakiutl groups are not more specialized in their right hand proficiency than the youngest Caucasians. These results support the contention that the Kwakiutl lack extreme behavioral asymmetry of the right hand.

When each age group within cultures is compared, a rightward shift in proficiency is noted. The age 4 to 6 groups of both cultures are concentrated in the ambi-handed portion of the distribution, and demonstrate little specialization of either hand. The age 10 to 12 Kwakiutl and Caucasian groups are concentrated in the right-handed portion of the distribution and demonstrate increased proficiency in the right hand, while the adults of both cultures demonstrate increased rightward proficiency. The Kwakiutl demonstrate significantly less right hand proficiency at all age levels than the Caucasians, however. The adult Kwakiutl and Caucasian distributions differ significantly from each other by culture, $\underline{KD}$ (120)=.5333, $\underline{p}$ <.001, but not from their corresponding age 10 to 12 distributions within culture (Kwakiutl 10 to 12 and Kwakiutl adult: $\underline{KD}$ (120)=.1667, n.s.; Caucasian 10 to 12 and Caucasian adult: $\underline{KD}$ (120)=.2167, n.s.). The age 10 to 12 Kwakiutl and Caucasian distributions differ significantly by

HAND PROFICIENCY DIFFERENCE SCORE DISTRIBUTION

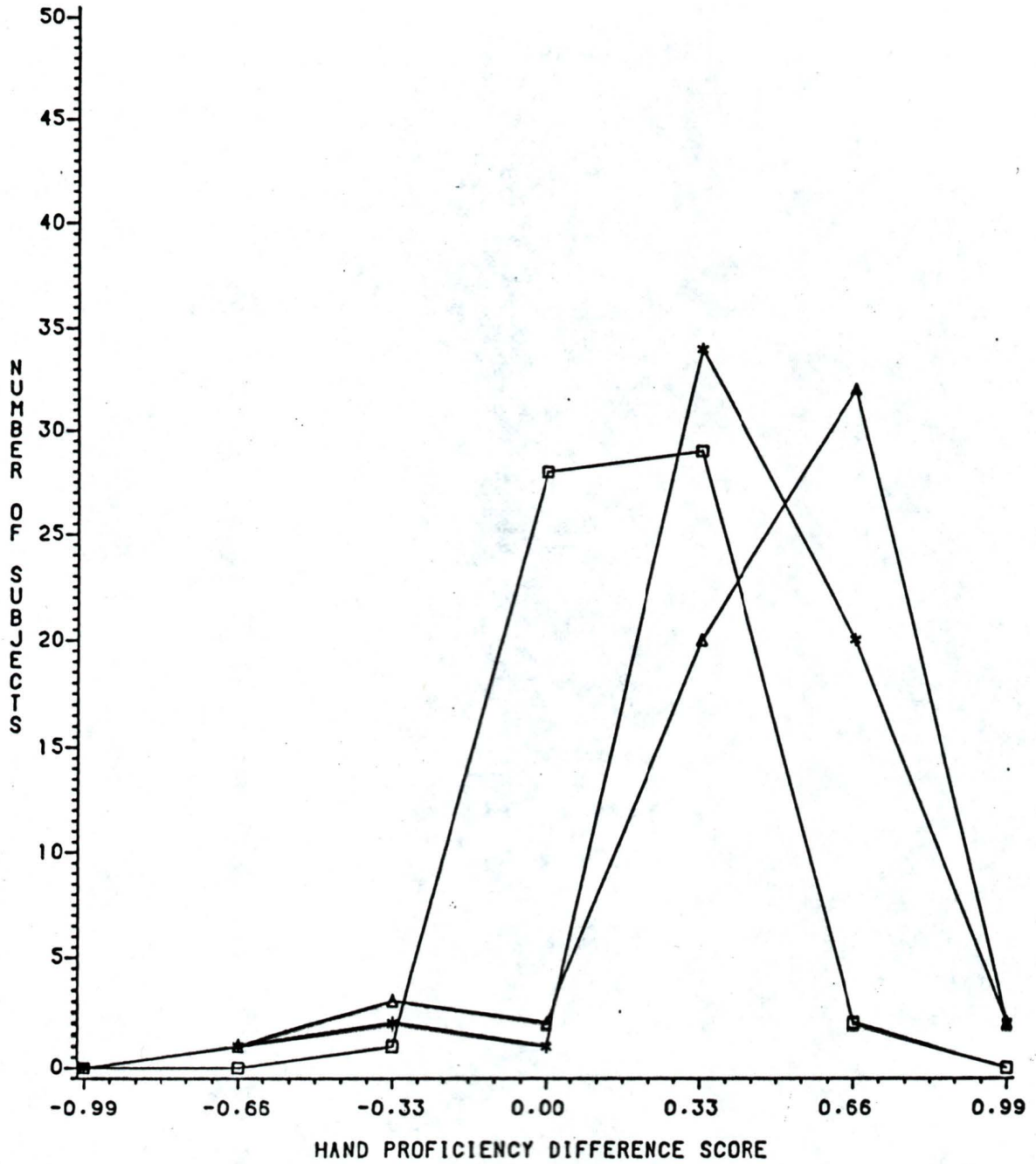
(R-L/N)
KWAKIUTL BY AGE
FIGURE 15



AGE 4 TO 6=SQUARE
AGE 10 TO 12=STAR
ADULT=TRIANGLE

HAND PROFICIENCY DIFFERENCE SCORE DISTRIBUTION

(R-L/N)
CAUCASIANS BY AGE
FIGURE 16



AGE 4 TO 6=SQUARE
AGE 10 TO 12=STAR
ADULT=TRIANGLE

culture, KD (120) = .5000, p <.001. The age 4 to 6 Kwakiutl and Caucasian distributions also differ significantly by culture, KD (120) = .3667, p <.001.

In summary, these results demonstrate consistent differences in handedness behavior on a number of measures between the Kwakiutl and Caucasian samples. These differences between cultures might best be described in terms of the ambi-handed behavior. A greater proportion of the Kwakiutl distribution, for both Hand Preference and Hand Use (as evaluated by the two self-report questionnaires), are ambi-handed when compared to the Caucasian sample. There are fewer right-handed Kwakiutl than Caucasians, and fewer left-handed Caucasians than Kwakiutl. The Hand Proficiency Test confirms a similar behavioral difference between these two cultures. The Kwakiutl obtained a much smaller (R - L) difference score, reflecting more equivalent ability between their two hands rather than the strong right-handed proficiency seen in the Caucasian sample.

When culture by age effects are examined, a different trend across age levels is found for the two cultures on all three variables. The Kwakiutl pattern is one of an initial ambi-handed preference, use and proficiency at age 4 to 6, followed by a shift to increased right hand preference, use and proficiency at age 10 to 12 and a final return toward the initial ambi-handed level at adulthood. The Caucasian

pattern is one of initial ambi-handed preference, use and proficiency at age 4 to 6, followed by increased right hand preference, use and proficiency at age 10 to 12 and a final increase in right hand use at adulthood.

NOVEL FINDINGS

INTER-ITEM RELIABILITY OF IDENTICAL HAND USE AND PREFERENCE ITEMS

Inter-item reliability within this design is important for a number of reasons. North American Indians are generally reported to have a different test-taking attitude and thus may respond differently in a unique situation (Gaddes, McKenzie and Barnsley, 1968; Havighurst, Gunther and Pratt, 1946; MacArthur, 1968; Rogers, TenHouten, Kaplan and Gardiner, 1977). A differential verbal ability is commonly reported (Dawson, 1977; Taylor and Skanes, 1976) as well as a different cognitive style (Rogers et al., 1980). It is possible that some of these factors may influence the reliability of test-taking behavior. Therefore, inter-item reliability was measured by the inclusion of the items ball, hammer, scissors and cards in both the Hand Use and Hand Preference Inventories. Inter-item reliability was then determined by first excluding all ambi-responding subjects from both cultures. All the remaining individuals were assigned to either of two groups depending upon whether or not they remained consistent in their answers to the four

repeated items across the two tests. For example, if one answered under both testing circumstances, that they threw a ball with their right hand, they were considered consistent and included in the consistency rates. The reason for excluding all ambi-responders in determining the reliability of this sample was based on current studies of reliability. Of the few such studies undertaken so far (Coren and Porac, 1978; Rackowski, Kalat and Nebes, 1974), reliability rates were based on small samples composed almost entirely of right-handers. There are a greater number of ambi-responders in the Kwakiutl population and these individuals, by definition, are not consistent in their handedness behavior. The inclusion of such subjects in determining reliability would, therefore, be misleading as the rate of inconsistent responses would be artificially increased. The inter-item reliability for this sample was greater than 90% for all items and not significantly different when compared with the data of Rackowski et al. (1974) on any of the four repeated items. Table 8 presents the consistency rates and significance tests between this sample and that of Rackowski et al. (1974).

TABLE 8

INTER-ITEM RELIABILITY ON THE REPEATED ITEMS COMPARED TO THE RESULTS OF RACKOWSKI ET AL. (1974)

ITEM	% CONCORDANCY EXCLUDING ALL AMBI-RESPONSES	% CONCORDANCY RACKOWSKI ET AL. (1974)	Z-SCORE
With which hand would you throw a ball to hit a target?	90.30 (N=329)	93.00 (N=27)	-.46
With which hand would you use scissors?	95.04 (N=326)	94.00 (N=27)	.24
With which hand would you hold a hammer?	95.70 (N=315)	97.00 (N=27)	-.32
With which hand do you remove the top card when dealing?	91.12 (N=277)	100.00 (N=27)	-1.60

$p < .05$*, $p < .01$**, $p < .001$***

CONCORDANCE AMONG HANDEDNESS MEASURES

Hand proficiency and preference are generally reported as separate variables, which although related are not consistently correlated (Porac and Coren, 1981). The intercorrelations vary by the sample (depending on the numbers of right or left handers) and by the particular instruments used for measurement. For instance, right hand grip strength correlates only 35 % with right hand preference (Provins and Cunliffe, 1972) and 25 % with left hand preference. This discrepancy is consistently reported in the current literature so it is of interest to be aware of the degree of concordancy between the preference and proficiency measures selected for this investigation.

Concordancy rates were computed for culture across the variables of writing hand and hand proficiency, and represent the proportions of each culture that write with their right hand and also demonstrate right hand proficiency. The Caucasian concordancy rates are not significantly different than those reported by Satz (Note 8). 97.22% of the Caucasian right-handed writers demonstrate a right hand advantage on the Proficiency Test while 98.63% in Satz's sample did, $Z = -1.18$, n.s. However, the Kwakiutl right-handed writers did not demonstrate the

same agreement between the two tasks. Only 84.44 % of the Kwakiutl who write with their right hands demonstrate a right hand advantage on the Hand Proficiency Test. When this proportion is compared against the Caucasian proportion, a significant difference is found, $Z = -4.20$, $p < .001$. This suggests either that a cultural bias may be affecting the Kwakiutl responses or that writing hand may be a less reliable predictor of behavioral asymmetry in this cultural group.

DISCUSSION

The results of this study support the hypothesis that the Kwakiutl are more ambi- and left- handed and suggest that one or more of the following play a role in the expression of handedness behavior: environmental or social pressure, cultural demands and genetic base rates.

The results of the cross-cultural comparisons and the age by culture comparisons on the three handedness measures will now be discussed within the context of current handedness theory. Those subject attributes which may have specific influence on the performance and preference variables will also be addressed with regard to current theoretical perspectives and to the control measures taken.

Finally, novel findings and speculations about certain trends or unexpected results will be commented on in the interest of developing future cross-cultural hypotheses.

CROSS-CULTURAL COMPARISONS ON HANDEDNESS

The two cultural groups differed significantly on all three measures of handedness, supporting the hypothesis that the Kwakiutl are more ambi- or left- handed on both self-report and behavioral measures than the Caucasian sample. A 15% difference in the incidence of right-handedness was found.

Dawson's (1972, 1977) position that societal pressure to conform influences handedness such that in strict, agricultural and schooled societies, a lower incidence of left-handedness occurs and in permissive, hunting societies a greater incidence occurs is supported by the results of this study, but with some reservations. The Kwakiutl, traditionally a fishing and hunting society, do have a lower incidence of right-handedness. If measured by writing hand, only 77.18% are right-handed. This is the lowest percentage documented in any cross-cultural comparison. Of the remainder, 6% are functionally ambi-handed for writing. However, as there was no direct measure of the degree of social pressure or conformity in this study, it is not known whether the Kwakiutl are permissive or nonconforming according to Dawson's (1972, 1977) specifications.

The most interesting results with regard to the handedness differences between cultures were those on the

Hand Proficiency Test. The distributional and mean differences, when compared between hands and on the difference score, reflect a basic difference in the performance of the hands across cultures. Most surprising is that the left hand performances between the two groups are equal while the right hands are not (see Figures 8 and 9). The Kwakiutl sample demonstrated little performance difference between their right and left hands while the Caucasian sample had significantly greater right hand proficiency (see Figure 10). Koch's (1933) distinction between unimanual and bimanual tasks suggests one possible explanation of this difference. Most of the daily tasks in the Kwakiutl culture, as documented by Boas (1921), required the bimanual cooperation of both hands, often in supportive roles and sometimes with both in dominant roles. Digging clams or canoe paddling require bimanual use with both hands gripping the paddle or clam stick; carving a totem pole requires both the left and right hand to act independently at times depending on which side of the pole one is working on (both the left and the right must be able); cleaning fish requires the simultaneous and cooperative use of both hands - one in a supportive role, the other in a 'dextrous' role. If the Kwakiutl culture requires more frequent performance of bimanual than unimanual tasks, then the smaller performance difference between their two hands may be due to this cultural difference in the types of activities.

However, this supposition remains to be investigated.

Aside from the apparent difference between the two cultures in the amount of time spent doing the practical, bimanual tasks required in daily living, another difference in the social requirements between the two cultures is the amount of time spent doing unimanual tasks such as writing. The Kwakiutl have had no graphology for their language and have only acquired the English graphology relatively recently in their history (in the last 50 years compared to 10,000 years without). Most Kwakiutl have spent relatively less time in the Caucasian educational system (8 years average) and many do not write once they leave school. On the other hand, Caucasians have been literate for at least 400 years in North America and for several millenia in Europe (Gelb, 1963). The Caucasian averages 12 years of education and writing is a common daily activity for the majority, even with the cessation of education. Downing et al., (1975), in their study of reading and writing readiness, suggest that these differences are of substantial impact and result in both a functional (motoric) and conceptual difference in readiness to learn to write. The effect of cultural differences in expectations regarding writing and the consequent practice effect, as they are manifested during the school years, may be another possible explanation of the data.

AGE BY CULTURE COMPARISONS ON HANDEDNESS

The three age levels were sampled in the interest of developing further hypotheses with regard to differences in handedness behavior due to developmental or environmental influences. Gesell and Ames (1947) reported that the development of handedness formed a variant and uneven pattern beginning with left hand use at age 16 to 20 weeks and, after many shifts including bimanual and bidextrous use, culminated in the invariant use of the right hand at age 9 to 10 years. Their research is supported in part by the results of this study which found no difference in Hand Preference in the Caucasian groups between the ages of 10 to 12 and adult. However, the Kwakiutl age 4 to 6 demonstrated significantly greater variability than did the Caucasians age 4 to 6, on both Hand Use and Hand Proficiency suggesting an already established difference in handedness behavior at this early age.

As well, the Kwakiutl adults had an increased incidence of left- and ambi- handedness when compared to the Kwakiutl age 10 to 12 group. The data suggest a differing developmental or cultural influence pattern for the Kwakiutl which is N-shaped. There is initally more left- and ambi-handed behavior at age 4 to 6, followed by an increase in right-handed behavior during school (age 10 to 12) and a decline in right-handed behavior in the adult sample. The

Caucasian pattern is one of increasing right-handed behavior from age 4 to 6 to adulthood. It is not known whether this differing pattern emerges as a result of increased environmental pressure (in the form of writing and social pressure to be like others) during school years or if it represents a differing developmental pattern (where the right-shift is slower or absent in a greater proportion of the Kwakiutl population).

If the data are conceptualized in terms of ambi-handed behavior and deviation to the right or left of this, the basic difference between the two cultures is evident. Developmentally speaking, handedness behavior occurs initially in this sample as random behavior which is represented by an absence of preference and proficiency in many individuals of both cultural groups. This accounts for the greater proportion of apparent ambi-handers in the age 4 to 6 groups of both cultures. As the samples age, several factors act to increase preference and proficiency in one hand over the other. These include the unfolding of the genetic predisposition, the strength of the socio-cultural/ environmental pressures and the practice of certain tasks over age. All individuals become more strongly sided as they age as a result of increased social pressure, practice and maturation.

The Kwakiutl ambi-handed group at age 4 to 6 may be comprised of individuals who are latent in developing a preference because of little social pressure and also because of a greater number of genetically atypical individuals (without the right-shift factor, some of whom will later become left-handed). The Caucasian ambi-handed group at age 4 to 6 may be made up of a smaller number of genetically atypical individuals and consequently, with the greater influence of social pressure to be right-handed, less will stay ambi- or left- handed. At age 10 to 12, social pressure may account for the increase in right-handed behavior in both the Caucasian and Kwakiutl samples. The larger portion of genetically atypical Kwakiutl individuals may be pressured to use their right hands, resulting in the rightward shift seen in the data. At adulthood, the mixed Kwakiutl group, relieved of the social pressure of the Caucasian environment, return toward their initial status and demonstrate more left- and ambi- handed behavior.

Further research is necessary to substantiate these initial observations, however. A longitudinal, prospective follow-up study of the children aged 4 to 6 would provide a much more stringent test of a developmental/ environmental hypothesis. A similar study of non-literate North American Indian children would also allow the investigation of these variables.

Further research should also address the construct of ambi-handedness. As demonstrated here, this may prove successful in discriminating between cross-cultural groups. However, the components of ambi-handed behavior need to be refined and a general definition agreed upon before such research can proceed. It would be of interest to reclassify the ambi-handers in this study into several groups. Those who were bi-dextrous and could perform all tasks with equal ability would form one such group. The numbers of such individuals is reportedly very small, however, 6% of this Kwakiutl sample demonstrate functional ambi-handed writing. Another group would include those who performed an equal number of given tasks with each hand, demonstrating equal specialization for specific tasks. A final group would include the remainder who demonstrate some degree of preference and proficiency with both hands for some tasks. This division in the types of ambi-handed behavior may lead to a better comprehension of socio-cultural influence. Does ambi-handed behavior occur as a result of a lack of pressure to be like others or as a result of specific rules concerning specific tasks? The Kantanganese (Verhaegen and Ntumba, 1964) have no ambi-handers as a result of strong social pressure and very specific rules governing the manipulative actions required by all manual tasks. Indonesians and other mideastern societies use the left hand specifically for cleansing waste from the body and the right

hand for eating and working. Some degree of ambi-handedness is trained by these specific rules. Lord Baden-Powell was able to use either hand to carry out many tasks. He advocated training armies and laborers to use both hands to improve efficiency. Kwakiutl carvers recognize the value of ambi-handedness and, in fact, many practice to attain a certain degree of proficiency with both hands. Right-handed carvers also employ the aid of left-handed carvers in doing intricate work on the left side of the totem pole.

INTER-ITEM RELIABILITY

Inter-item reliability for the total sample (when ambi-responders are excluded) was greater than 90% on all four items and therefore not significantly different than other investigator's reports (Rackowski et al., 1977). However, a comparison across cultures revealed that the Kwakiutl were less consistent on the 'ball' item. Levy (1974) posits that such a difference may be indicative of a cultural effect in that activities, other than writing, may be performed more spontaneously rather than as if dictated. Hildreth (1948, 1949) reported 11.1% sinistrality for spoon holding, cup holding, ball throwing and drawing as opposed to 8.2% sinistrality for writing, in the same sample of American children, age 2 to 4. In view of the age group and the expected cultural difference in tolerance of left hand use,

the age 4 to 6 group concordancy rates were examined. A similar decrease for both cultural groups of this age was found. The Kwakiutl age 4 to 6 were 70.9% concordant while the Caucasian age 4 to 6 were 77.36% concordant. The Kwakiutl adults were 98.1% concordant and the Caucasian adults were 98.3% concordant. Ball throwing, in this study, is affected by age level, and at the earlier age may reflect either unestablished preference or unrestricted cultural influence.

CONCLUSIONS

Cultural differences exist between the Kwakiutl and Caucasian samples in this study on the variables of Hand Use, Hand Preference and Hand Proficiency.

The Kwakiutl report and demonstrate a greater incidence of left- and ambi- handedness on a Hand Use Inventory, on the Hand Preference Inventory, and on a Hand Proficiency task. This difference seems to be largely accounted for by the greater incidence of ambi-handed behavior in the Kwakiutl. On the Hand Proficiency Test, both Kwakiutl and Caucasian samples scored equally well with the left hand but the Kwakiutl right hand performance was less than the Caucasian right hand performance. This is interpreted as representing greater symmetry of behavior in the Kwakiutl group. The left and right hands of the Kwakiutl are much

closer in the degree of proficiency than in the Caucasian sample, who demonstrate a strong right-handed bias. It is interesting to note that the Kwakiutl adults have better left hand performance than the Caucasian adults on this test which implies that a functional advantage with the left hand occurs over age. This occurs perhaps because of greater left-hand use in their particular cultural milieu. Another explanation is that handedness becomes more strongly lateralized over age and, consequently, those Kwakiutl left-handers are more proficient when adult than when age 4 to 6 or 10 to 12.

The differences in Hand Preference and Proficiency between the Kwakiutl and Caucasians sampled are supported by the data. No single theory presented thus far is able to account sufficiently for this difference and it is likely that multiple factors are responsible. That these differences exist is important and interesting in itself; the why will have to be answered with the generation and testing of future hypotheses.

An environmental or societal pressure theory, in order to account for these results, must first be quantified: the particular variables which make up the conformity/permissive dimensions or the unimanual/ bimanual use must be researched, formally stated and then tested.

The influence of writing, and its requisite specialization requirements of the right hand, could be tested by the administration of Hand Use and Proficiency Tests to illiterate populations such as those in rural Texas, Kentucky, Missouri or Russia.

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PHOTOGRAPH CREDITS

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Appendix A

HAND USE INVENTORY

Name _____ Sex ____ Age ____

Indicate hand use:

1. To write a letter legibly	__left __either/both __right
2. To throw a ball to hit a target	__left __either/both __right
3. To carve with a knife	__left __either/both __right
4. To cover a number at Bingo	__left __either/both __right
5. At the top of a shovel to move sand	__left __either/both __right
6. To hold a match when striking it	__left __either/both __right
7. To hold scissors to cut paper	__left __either/both __right
8. To hold thread to guide through the eye of a needle	__left __either/both __right
9. To hammer a nail into wood	__left __either/both __right
10. To deal playing cards	__left __either/both __right
11. To hold a toothbrush while cleaning teeth	__left __either/both __right
12. To unscrew the lid off a jar	__left __either/both __right

Appendix B

HAND PREFERENCE INVENTORY

Name _____

Sex ____female ____male

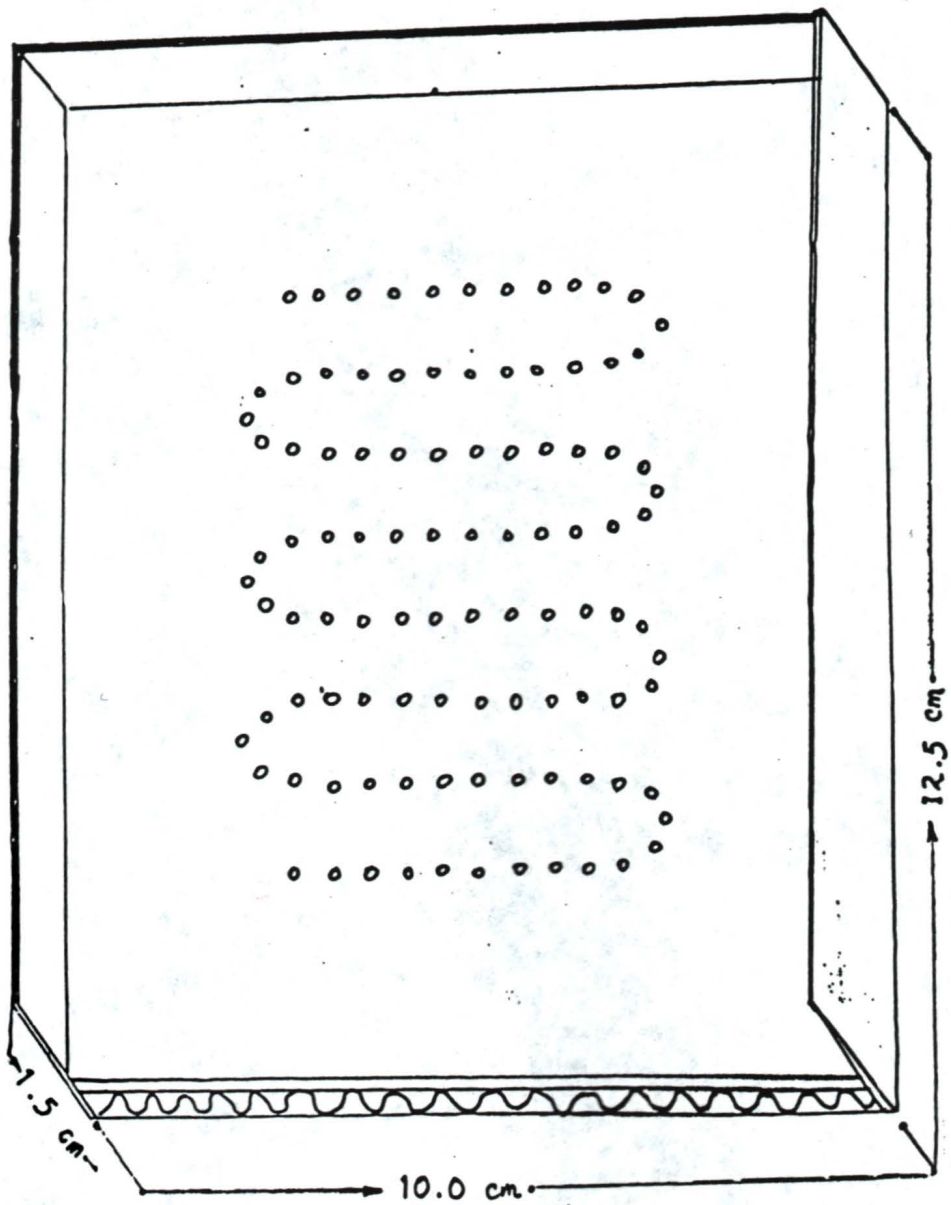
Age ____

Please check the response that describes you best.

1. With which hand do you use an eraser on paper? __left __right __both
2. With which hand do you remove the top card when dealing? __left __right __both
3. With which hand would you throw a ball to hit a target? __left __right __both
4. With which hand do you draw? __left __right __both
5. With which hand do you use scissors? __left __right __both
6. With which hand would you hold a hammer? __left __right __both

Appendix C

HAND PROFICIENCY TEST



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Title of Thesis

HAND USE, PREFERENCE AND PROFICIENCY: A CROSS-CULTURAL COMPARISON OF KWAKIUTL AND CAUCASIAN SAMPLES

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April 16th, 1983.

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