SENSORY DOMINANCE : AN EXPERIMENT ACROSS CULTURES

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ABSTRACT

Physical and intellectual differences in the home environment of Xhosa and White children suggested that the interaction of touch and vision in situations of sensory conflict and the development of dominance may be different in children from these homes. Children aged 5-13 years were tested on apparatus which created a conflict of tactual and visual judgement about the perceived size of the stimulus. Xhosa and White subjects performed similarly except when only tactual judgement was allowed and the Xhosa group were less influenced by touch. The study concludes that for children touch and vision contribute equally to the resolution of sensory conflict when both senses are active in size-judgements and when only one mode is allowed for judging then the resolution is biased towards this mode. This outcome is different from that of experiments with adults and has implications for theories derived from them.

CONTENTS

1. INTRODUCTION

In recent years a number of investigators have studied the question of perceptual conflict which results from simultaneously presenting conflicting information to two different sense modalities. Several studies, notably those of Rock and Victor (1964) and of Rock and Harris (1967), have shown that when visual and tactual data differ, vision predominates; i.e. a unified impression, based almost entirely on vision emerges. These findings were a direct contradiction to the traditional notion that from infancy, touch educates vision. This would imply that the development of visual organisation is based on tactual experience.

The subjects in these initial experiments were adults, but subsequently, studies using children as subjects have been carried out, to see if there are age-related changes in cross-modal matching ability, Milner and Bryant (1968), also Connolly and Jones (1970), or specifically to see if there is a developmental shift over age in the relative effectiveness of touch over vision; Kaufman, Belmont, Birch and Zach (1973).

The results have been very disparate and claims regarding developmental increments in cross-modal integration have been criticised[1] on the grounds of faulty interpretation and insufficient within-modal controls to show changes in this ability.

This study, which is directed to investigating evidence of dominance in children's cross-modal perceptual activity, has two aims:

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[1] Milner and Bryant (1968), p.457.

1. To describe a pattern of development for the dominance of vision over touch for the sensory conflict situation,

and 2. to test the cultural universality of the phenomenon and its development.

To achieve the first of the two aims, it is necessary to select age-graded subjects, and to elicit from them visual and tactual matching or recognition responses, under intra-modal and cross-modal simultaneous input conditions.

The second aim depends for its fulfilment on the well-known fact that children who have very limited opportunities for manipulative play and related perceptual-motor activities, perform poorly on non-verbal tests of intellectual ability as they are handicapped in tasks which involve spatial relationships. This description fits the majority of the Xhosa children of Grahamstown, South Africa, where the study was done, and as their physical and intellectual environment is sufficiently different from that of their White counterparts, it was hypothesized that differences in sensory dominance might emerge, perhaps developmentally, if the subjects drawn from these two groups were to be compared.

If significant, such differences would indicate that sensory dominance of vision over touch is largely culturally determined, and this would have important implications for educational methods and training techniques.

2. SENSORY DOMINANCE

2.1 Defining "Sensory Dominance"

The term "Sensory Dominance" describes a phenomenon which occurs when two sensory modalities, such as vision and touch, signal different data and when a unified impression results, biased toward one of these modalities. The essential element required for measurable dominance to be manifested, is a sensory conflict situation. To create such a conflict where two sensory impressions, received through two sense systems, yield different information about a stimulus object, it is necessary to introduce a distorting device which produces false information to one of the sense systems. The subject who is unaware of the distortion, will show in his response how he resolved the conflict. If the conflict is not cognitively resolved (through the subject's accidental detection of the distorting device), the result will be a unified impression, usually showing some influence from both modalities, but biased towards one of them. It is here that the dominance of one modality over another will emerge. This type of information is usually elicited by setting a cross-modal task in which the subject must make an equivalent judgment of size, forms or pattern.

Investigators[1] of the sensory dominance phenomenon have used a variety of ways of producing a sensory conflict. Most of them introduced some form of distorting optical system which produced changes in the shape or size of the stimulus object.

Extra practice in one of the two modalities, interpolated into

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[1] Rock and Victor (1964); Rock and Harris (1968).

performance in the other, is another way of producing conflicting influences. This method was used by Kaufman et al (1973).

The control, which is necessary if results thus obtained are to be considered genuinely cross-modal, is to include in the design, matching tasks involving each of the two modalities alone, i.e. within-modal tasks, as well as cross-modal tasks where both are involved. See Milner and Bryant (1968), page 457.

2.2 Dominance of Vision and Touch

2.21 The studies of Rock, Victor and others

The historically prevalent belief that vision is educated by touch, has been strongly questioned by numerous investigators since Rock and Victor (1964), in a study titled: "Vision and Touch: an experimentally created conflict between two senses", claimed that when adult subjects made shape or size judgments of conflicting visual and tactual information, vision completely dominated touch. Rock and Victor also stated that distorted visual impressions would induce changes in touch experience so that objects would feel the way they looked.

These conclusions were drawn from several experiments designed to study the manner in which adult subjects cope with conflicting sensory information involving vision and touch in various input situations.

The experimental procedure used by Rock and Victor shared a basic strategy, viz. that the subject viewed a standard object[1] through

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[1] A 25 x 1 mm white plastic square attached to a thin black metal stem.

a transparent plastic lens[1] which compressed the image along one axis, i.e. it reduced one dimension of the object's visual shape. Thus a square block appeared to be rectangular, reduced, in this case, along the horizontal axis. This block, mounted on a slender black metal stem was inside a box into the front of which was set an eyepiece - opposite the distorting lens. Hanging down over a large opening directly behind the block was a piece of black cloth, and as the subject looked at the stimulus block he had to reach behind and grasp it through the cloth. After simultaneously viewing and grasping the standard, the subject could then be asked to select a comparison object which he judged to match his impression of the standard.

These authors had two questions to consider when designing their experimental procedure, viz: 1) how to measure what the subject was experiencing, and 2) how the comparison-object should be represented. The fact that a mechanically contrived deception will cease to produce any special perceptual effect once a naïve subject becomes aware of the deception, implied that once the expectation of unity ceases, one modality would no longer dominate another. Rock and Victor therefore decided to preserve the naïveté of their subjects by using each subject once only, thereby obtaining only one judgment from each. Their design included three experiments with three conditions in each. The three conditions in each experiment were as follows:

1. In the experimental condition, the subject viewed the standard and at the same time grasped it manually. The subject was not

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[1] The optical lens element was a transparent piece of plastic, 0,6 cm thick, with parallel sides. The element was bent around the vertical axis to form a portion of a thick walled cylinder. Rays striking the plastic at an angle other than 90^{o} were displaced. This effectively compressed the image along one axis only. (Rock and Victor, 1964, p.594.)

told what his task was to be afterwards, until after exposure to the standard.

2. In the vision control condition, the subject only viewed the standard.
3. In the touch control condition, the subject only grasped the standard.

In all conditions 5 seconds were allowed for exposure to the standard.

In the first experiment the subjects made drawings of their impression of the shape of the standard. They were not asked to attend to the absolute size of the standard, only to its shape. The drawings produced under the three conditions were measured, and using the relative proportion of length to width as the measure representing the perceived shape, it was shown that the experimental group and the vision-control group yielded mean scores of 1.85 and 1.9 respectively, while the touch-control group's mean score was 0.98. This means that the groups using vision and touch or vision alone, were drawing rectangles of almost a 2 : 1 ratio, while the touch-control group were drawing near perfect squares. This, the authors claim, indicates that vision was completely dominant.

In the second experiment the method used was that of selecting a comparison match by vision alone, under the same three conditions as before. This means that the subjects looked at and grasped the standard, but he only viewed the comparison objects from which he had to make his selection. These were arranged as an array of rectangles ranging in width from 8.6 to 31.8 mm. The results which were as follows, show a clear favouring of a visual resolution:

Condition	Mean Width
Experimental group	14.1 mm[1]
Vision-control group	13.4 mm
Touch-control group	23.1 mm

[1] Two subjects gave matches in the direction of touch. (Rock and Victor, 1964, p.595.)

Rock and Victor comment as follows on this experiment:

> "This procedure may be thought to be biased in favour of a visual resolution, since the subject selected by using vision alone. However he was not aware that he would have to make a match from vision, and therefore he could not be said to be concentrating more on vision in his perception of the standard because of the comparison task.
>
> It could also be argued that it should not make any difference what comparison technique was used, since the subject received a unitary impression and would communicate this impression by whatever type of comparison he made. That is, once he has 'decided' what he had experienced, it should not be crucial which method or modality he employed to tell us what he had experienced."

In the third experiment, comparison with the standard was made by touch alone. The same array used in experiment two was used here. The subject grasped the first rectangle and then moved his hand along the range, feeling each rectangle in turn. The size sequence was presented in ascending order for half the subjects, and reversed for the other half. The results for the three experimental conditions were:

Condition	Mean Width
Experimental group	14.5 mm
Vision-control group	14.1 mm
Touch-control group	20.5 mm

Note: The objective width of the block was 25 mm and in all the vision-control experiments, the outcome indicated that the effect of the optical compression was about one half.

The results of all three experiments therefore showed that, with few exceptions, visual impressions were dominant. Rock and Victor report that similar experiments in which the visual size of an object is altered by means of a lens, the resultant conflict was also resolved in favour of the visual mode.

An additional procedure at the end of some of these experiments on size served to illustrate the point regarding changes in touch experience which were mentioned in the first paragraph of section 2.21.

The subject was asked to look at and grasp the standard, and while doing so he was asked to close his eyes and open them again. Questioning revealed that 60% of the subjects tested reported that the object "felt" larger when their eyes were closed. The remainder reported no definite impression. Hence the authors maintain that "...vision is so powerful in relation to touch that the very touch experience itself undergoes a change. The object actually feels the way it looks." (pp.595-596.)

Another notable fact that emerged from this study was that while most subjects remained unaware of a sensory conflict, about one in five did detect the conflict and then showed a tendency to resolve it more in the direction of touch than the naïve subjects did. It is inevitable that despite every precaution, a subject might look up and gain an uncontaminated tactual impression which will suddenly make him aware of the contrived conflict.

Their answer to the question as to whether a unified impression would be experienced in the conflict situation, is therefore a qualified "yes". The naïve subject, unaware of the conflict, does have a unitary experience of the size of the object, and the experience agreed closely with its illusionary visual appearance.

In assessing the implications of these findings it is appropriate to distinguish between various aspects and components of touch perception since Rock and Victor admit that they made no attempt to do so.

J.J. Gibson (1962) distinguishes between active and passive touch. He defines "active touch" as an impression on the skin brought about by the perceiver himself, and "passive touch" as one brought about by some outside agency. Active touch is therefore an exploratory rather than a merely receptive sense, and Gibson suggests that it could also be termed "tactile scanning" by analogy with ocular scanning. Though this difference is very important for the individual, Rock and Victor made no attempt to differentiate the various aspects of touch perception. They state (p.596):

> "We are using the term 'touch' in the broadest possible way, to stand for any and all aspects of sensory experience based on the mechanical contact of the observer with objects which can yield information as to the properties of such objects."

Rock and Victor's (1964) subjects who suspected deception in carrying out their cross-modal discrimination task and who used active touch, responded differently than naïve subjects and were eliminated from the sample. On the other hand Miller (1972), designed experiments the purpose of which was to explore active and passive touch and the loss of procedural naïveté using form tasks with or without conflict. Both active touch and the loss of procedural naïveté were expected to enhance the use of the tactual information. The first experiment involved a vision/touch conflict and resembled that of Rock and Victor except that increased haptic activity in presentation and matching had been encouraged. Three experimental groups had used different combinations of active and passive touch. However there were no significant differences among the three groups. Thus, increased haptic activity, which results in a reduction of procedural naïveté, did not produce matches closer to the actual object (Miller, p.118) A significant fact is that this additional tactile scanning also failed to diminish visual dominance. Hence the Rock and Victor (1964) finding that a form conflict task led to visual dominance over touch, was confirmed, despite the increase in haptic activity permitted and despite the loss of procedural naïveté.

By contrast, the second experiment tested subjects on similar tasks but with simultaneous though not conflicting presentations of anomalous sensory input, i.e. the subject matched the tactual object independently of the visual information. Miller (1968) cited by Miller (1972). Also the procedures in this non-conflict task employed active touch and fully instructed subjects. Miller's (1972) results show: "...more veridical matches than when passive touch was employed, but this variable was equally potent for the experimental and control groups. $G\ (1,52) = 6.93 \quad p < .05$." This result differs from that of the first experiment in which no differences were observed with varying amounts of haptic activity. When visual and tactual information is simultaneous but not conflicting, touch is not dominated by vision. (See Fig. 5, page 120, Miller, 1972.)

The findings resulting from the study by Rock and Victor (1964) have continued to interest investigators and a considerable number of related studies on cross-modal sensory experience have been published since. A variety of optical devices like displacement prisms and reducing lenses have been used to provide the conflicting information. The most comprehensive of these subsequent research publications is that of Rock and Harris (1967).

In a review[1] of the 1964 experiments and of a number of similar studies[2] which illustrated the phenomenon of "visual capture", Rock and Harris confirm their rejection of the traditional idea that

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[1] Irvin Rock and Charles S. Harris, "Vision and Touch", in Scientific American, 216, 1967: 96-104.

[2] Researchers cited by Rock and Harris:
Hamilton, C.R., Calif. Institute of Technology.
Hochberg, Julian
Hay, John C., Pick, H., Cornell
Hay, John C., Pick, H., and Ikeda, K.
Nielsen, Torsten

vision is educated by touch. This publication also included a number of new experiments designed to produce further evidence in support of their claim[1] regarding visual dominance and they could state finally that each of the separate experiments included in the 1967 study, "Vision and Touch", showed that: "...when a subject's sense of touch conveys information that disagrees with what he is seeing, the visual information determines his perception." (p.100).

Rock and Harris do however concede that this is an immediate effect and that important questions regarding continuous experience have been left unanswered. They pose the question: What will be the effect of continuous perceptual experience using two modalities for long enough to allow a genuine change in perception to take place? They consider that in the previously cited experiments, it could be that vision suppresses touch only temporarily, with the result that as soon as a person closes his eyes his touch perceptions return to normal. Another possibility mentioned is that although vision is at first dominant, it could eventually change to match touch. This suggested that the converse could also be true, viz: "...with sufficient exposure the sense of touch may be altered so that mis-perceptions by touch persist even after vision is blocked." (p.99).

In order to find answers to these questions, Rock and Harris considered experiments in which changes in perception might have been expected to occur because the exposure to the conflict was continued over a period of time. They chose experiments in which displacement prisms were used, and where the basic strategy involved asking the subject to:

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[1] Rock and Harris (1967), p. 99, column 1.

1. point at a specific object in a numbered array, without being able to see his hand,
2. point repeatedly at e.g. the centre target with one hand,
3. point at various targets without wearing the prisms, but with the hand hidden.

(Throughout, the head is kept steady by e.g. a biting device.)

Subjects typically showed an adaptation, or shift in pointing, with the hand used while wearing the prisms, but little or nothing with the other hand. It could be contended that this visual perception improved because touch educated vision in spite of the displaced retinal image. However Rock and Harris point out that the converse could be equally correct, since the subject, still seeing the object as displaced, mistakenly feels that his hand is displaced - when it is actually pointing ahead. Greater accuracy after repeated exposure could indicate adaptive change in the position sense of the adapted arm.

In order to find out which of the two explanations was correct, C.R. Harris and J.R. Harris carried out a series of experiments using the same basic strategy of pretest, adaptation and retest. In the 1st and 3rd conditions a black cloth was used to cover the arm. These three conditions were:

1. Pointing at visual targets seen through displacement prisms,
2. Pointing in the direction of sounds with eyes closed,

and 3. Pointing straight ahead.

They found that the subjects showed a large shift in pointing with the adapted hand on all three retests, but little or none with the unadapted hand.

Rock and Harris cite these findings to strengthen their own argument regarding visual dominance. They state that the findings clearly rule out the possibility that the adaptation was due to a change in visual perception. In support of their conclusion, that the adaptation involved a change in the "position sense" of the adapted arm, they add:

> "...if the subject had learned to perceive the visual target in a new location, he should point at that new place with either hand. What actually happened was that when our subjects were asked to point at a target, they pointed in one direction with one hand and in a different direction with the other."

To this they add:

> "...if adaptation were only a change in visual perception, it should have no effect on tests performed with the eyes closed, yet about equally large adaptive shifts were found when subjects pointed at sounds or in the straight-ahead direction." [i.e. in the third condition.]

Rock and his co-workers consider another potential explanation of adaptation to prisms, viz. that it is due to the learning of new motor responses; the subject simply learns to make movements appropriate to the altered visual stimulus. A subject could therefore correct his motor movements without any change in his visual perception having taken place. Here reference is made to the classic work of Stratton (1897) who spent several days wearing lenses that turned everything upside down. Stratton reports that he tried to duck under objects he should have climbed over, he made wrong turns and missed when he reached for things. After a while, however, he adapted: he behaved normally again, reacting appropriately in spite of the abnormal retinal image. The conclusion drawn from this experiment was that radical adjustments in vision were necessary to enable the subject to see normally again. This conclusion was challenged by Rock and Victor (1964), who deny that Stratton's learnt ability to avoid his initial motor errors was the result of a visual change. They hypothesised that he did not learn to see normally through the inverting lenses, but that he learned to adapt his motor movements.

To investigate the possibility of the adaptation being attributable to pure motor learning, it was necessary to design an experimental condition in which the location of the hand was judged without moving it. As it had been previously shown that the unused hand had not been affected by the adaptation procedure, this was done by testing the subjects' ability to estimate the distance between his hands when blindfolded, both before and after one arm had been adapted as previously described. The experimenter placed the right (adapted) hand at a predetermined location on the table in front of the subject who was then asked to place his left hand at a specified distance from his right hand. The experimenter moved the right hand to a new location and the process was repeated. Noted that the adapted hand was given no opportunity to learn any new motor responses, so the subject was forced to rely on his position sense in judging the distance. Results showed an error biased in the same direction as that of the visual shift. Rock and Harris interpret this as a clear demonstration of the fact that the subject's "position sense" had indeed been altered to the point where he misperceived the location of his other hand.

Their earlier observations with the reducing lens seems to contradict this finding. Although vision dominated touch when both senses were active, judgments made by touch alone were more accurate. This leads Rock to raise the question as to whether the apparent change in tactile perception created by the conflict situation would outlast the conflict situation if it were to continue for a longer time. In collaboration with three co-workers,[1] Rock investigated also this

[1]Arien Mack, A. Lewis Hill, Laurence Adams.

question experimentally. Prolonged exposure to conflicting data from vision and touch was achieved by once more using a reducing lens and by giving the subject 30 minutes in which to grasp (through a cloth) and view, each of an array of squares mounted on a revolving wheel. Two matching tests were given before and after the thirty minute exposure, to find if visual or tactile perception had changed. The exposure certainly changed the subject's size judgment as manifested by his matching responses: "...for a felt object and a seen object to seem equal to him, the visual object had to be smaller than before." (Rock and Harris, p.103.)

However, these results did not reveal which sense modality had changed to yield the new match. Whether objects looked larger or felt smaller had still to be established. To do this, Rock et al used a "remembered standard" test. In the test of visual size the subject had first to practise looking at a luminous square in a darkened room and then match it visually from immediate memory. Then followed the thirty minute exposure to the conflicting data produced by the reducing lens, after which the subject was once more asked to select visually, a square the same size as he remembered the standard to be. (The array used in the selection was luminous, so the choice was made in the dark.) If in fact the subject's vision had changed, he should now select a smaller square than he did before his recent conflict experience, because the square in question should now look larger than it is. This was however not the result: the subject selected a square that on the whole matched the standard accurately. This seems to indicate that there was no change in the visual perception of size.

Exactly the same apparatus and basic strategy was employed to test a possible change in the subject's tactile perception, viz: the subject had to feel the standard square before and after the conflict exposure period. The great majority of subjects selected a larger square after the thirty minute conflict experience than they had chosen earlier. This larger square now "felt" smaller than it did before.

The final experiment included in the Rock and Harris report, shows the effects of a more exaggerated conflict between vision and touch, namely looking through reversing prisms. Harris and Harris are cited as having demonstrated that vision is powerful enough to accomplish radical misperceptions in even as highly practised a skill as writing numbers and letters. Perception was affected to the extent that thirty per cent of the items were reversed or otherwise distorted when the subjects' view was blocked.

In their concluding statement Rock and Harris attempt to answer these final questions: When tactile information differs from simultaneously perceived visual information,

> "what happens during such a conflict to the information the sense of touch is providing? Is it blocked before it reaches the brain, is it ignored or is it transformed?" (p.104).

Although there is not complete concensus between these authors on all these points, they are agreed that after "sufficient exposure" to visual/tactile sensory conflict, there is a change in the sense of touch itself. They say:

> "Since the subject continues to misperceive by touch even with his eyes closed, he cannot be blocking or ignoring the information provided by touch. It is therefore a reasonable guess that the information is not blocked or ignored when his eyes are open either. Instead it must be transformed into new touch perceptions that are consistent with visual perception."

They are also unanimous in their agreement that, "...there is no convincing evidence for the time-honoured theory that touch educated vision and that there is strong evidence for the contrary theory."

2.22 Other relevant experiments

Miller (1972), some of whose findings regarding active and passive touch were discussed on page 9, in a further set of experiments based on Rock and Victor's method, confirmed their results, and tasks in which the implied conflict was varied allowed him to conclude that the cognitive component, the expectation of a unitary response, was the essential element in producing vision-touch conflicts, which were then resolved in the direction of vision.

Another hypothesis by Miller, namely that more accurate or practised tactual judgment would result in less reliance on vision, was not confirmed. Using a verbal questionnaire each subject was asked three questions to determine how the expectations of each may have influenced his matches. The questionnaire confirmed that subjects did not change their task approach over trials. Thus visual dominance was not diminished by haptic activity as predicted.

The converse of this hypothesis had been tested by Derrick and Dewar (1970) in response to an earlier study by Miller (1968). They argued that, "...if an increase in tactual accuracy would lead to less dominance of vision over touch, then a decrease in such accuracy should lead to increased visual dominance." (p.938). This hypothesis was tested in a study which partially replicated Miller's 1968 study, but manipulated "degree of tactual accuracy" in addition. They failed to find a statistically significant trend but expressed difficulty in reconciling this failure with Miller's concept that "...visual dominance occurs because visual information 'fills in' for tactual information which is less reliable."

In a critical introductory statement to their study "Cross-Modal Matching by Young Children", Milner and Bryant (1968), challenged the validity of the claims of certain investigators[1] that they have found age-related improvement in tasks involving the integration of perceptual information which comes through different sensory modalities. The experimental evidence on which these claims are based comes from studies in which children are made to match stimuli when these are presented in different modalities. All these researchers concluded that this result signifies a developmental improvement in cross-modal integration. [See p.458, Bryant (1968)]. The second author had published a separate paper in which he commented on the design of developmental studies of cross-modal matching and cross-modal transfer, saying that these studies failed to include the controls which were necessary to show changes in cross-modal ability. He states:

> "In cross-modal matching tasks, errors may be due to failures in recognising equivalence across modalities, but they may also be due to failures within one of the modalities concerned. For example in a task in which the choice stimuli are presented tactually and the standard stimulus visually, errors may be due to failures to match information across the two modalities, but they may also be due to a failure to discriminate the two-choice stimuli tactually. It follows that the improvements which have been found could be explained as improvements in discrimination within a modality rather than in matching information across modalities.
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> The control, which is necessary if improvements are to be shown as genuinely cross-modal, is very simple. It is to include within-modal as well as cross-modal matching conditions."

Rudel and Teuber (1964) are quoted as having included the necessary controls, but even they commit a design error by presenting certain stimuli successively and others simultaneously.

Because of this alleged lack of substantive evidence, either for or against the claim that cross-modal integration increases with age, Milner and Bryant themselves designed an experiment in which children

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[1]Abravanel (1968); Conners, Schuette and Goldman (1967); Birch and Belmont (1965); Blank and Bridger (1969)

between five and seven years of age were required to match shapes within- and cross-modally. It was argued that if there was a greater improvement with age in the cross- than in the within-modal conditions, the claim for a developmental improvement would be substantiated; if on the other hand, there was the same degree of improvement with age in both types of matching, this claim would have to be disallowed.

The crucial comparison in this experiment therefore concerned the relationship between the within-modal and the cross-modal matching conditions.

The two main results were, 1) that the developmental improvement that did occur was mirrored by a corresponding developmental improvement in the within-modal condition; 2) that as many errors were made in the tactual within-modality task as in either of these two cross-modal tasks. Milner and Bryant interpret these results as a clear indication that the age change which did occur in the cross-modal condition must be attributed to changes within the tactual modality, rather than to changes in organisation across modalities. They reject the validity of the studies in question and state:

> "Until it is properly shown at any age range and with any material that improvement with age is greater in cross-modal tasks than in within-modal tasks, the hypothesis of a developmental improvement in cross-modal organisation must be discounted."

Referring to results they also discuss the possibility that all errors in cross-modal matching can be attributed to failures in the tactual input, rather than to failures in the cross-modal organisation. Their tabled results show clearly that in within-modal matches the visual input is more accurate than their tactual input.

Note: In relating this finding to the present study it is important to remember that no perceptual conflict was included in the Milner & Bryant experimental tasks. Also, no indication was given to Ss as to

Hence in each cross-modal match (VT or TV)[1] there is always one good input (V) and one bad one (T), whereas in the TT matches two bad inputs have to be compared, i.e. TT matches should be the most difficult, assuming of course that errors are entirely due to the discriminality of the input. They add that in the case of the simultaneously presented stimuli, they can infer from the data that,

> "...a specifically cross-modal difficulty is constant with age (this is the main conclusion of the paper), but also that that difficulty is in fact negligible. This is a very important conclusion. It implies...that as soon as... a tactual discrimination can be made, the same discrimination can also be made cross-modally, when only one of the stimuli is given tactually."

This conclusion, however, does not apply when there is a delay of from 5 to 30 seconds between the first and second stimuli. Under these delays TT matches were no harder than VT or TV matches. It can be argued from this pattern of results that some of the errors in cross-modal matches were due specifically to failure in cross-modal organisation. If the same argument is again applied, viz. that only a significant difference between TT matches and VT/TV matches would be indicative of failure in cross-modal organisation, then the failures that did occur are still unaccounted for. Milner and Bryant suggest:

> "This cross-modal failure is probably the result of the imposed memory requirement since it is only present when a delay of 5 seconds or more is introduced. This suggests that there may be a tendency for stored representations of shapes to be more inaccessible for cross-modal than for within-modal comparison after a delay of a few seconds. It should be noted again that the degree of this cross-modal failure after delay is constant over age."

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the correctness or otherwise of their responses and therefore the numerous trials cannot be compared with e.g. Becker-Carus' "learning period" which he used to lower the tactile discrimination threshold.

[1]VT: A visual stimulus matched through the tactile modality, i.e. by touch alone.
TV: A tactile stimulus matched visually only.

Of particular relevance to the present study is that of Kaufman et al (1973) who also used young children as subjects, and although not concerned with dominance where the sensory information was in direct conflict, they were nevertheless concerned with the organisation of the tactile and visual sense systems.

Their study was a response to the claims that, "...many of the changes in behaviour that occur with age are subserved by systematic changes in the relationship among the sensory systems", and to the conflicting results[1] from explorations of these hypothesised shifts in sense system hierarchy. They therefore sought firstly to determine if there is a developmental shift over age in the relative effectiveness of touch versus vision, and secondly, to study at the same time the nature of the age changes in the interrelationships between these two sensory modalities.

To do this it was necessary to select tasks which are equivalent across sense modalities - as regards cognitive demands - and which fall within the cognitive competence of very young and older children. Simple reaction time was considered to be such a task, and two separate RT procedures were developed to answer the questions. The first task, called 'Interpolation', represented a sensory interference model which yielded information about the interrupting effects of vision to touch, and touch to vision. The second task, 'Prestimulation', was a priming model which yielded information concerning the effects of tactual priming upon visual RT and vice versa.

In the Interpolation procedure, the subjects did a set of trials in one mode (e.g. RT to light or to touch) followed by a three minute

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[1] Rudel and Teuber (1964): found no age-related hierarchical shift. Fisher (1965) and Schopler (1966) cited by Kaufman: found different hierarchical organisations at different ages.

intervening period of stimulation in the other mode before doing a second set of trials in the original mode, i.e. TVT or VTV. The analyses were used to answer two questions:

1) Whether interpolated stimulation in the modality other than that used for the RT signal, resulted in an increase in RT at all ages, and
2) If the combination of modalities used in signal and interpolation had different effects on RT at different ages.

The answer in both cases was a clear affirmative. In the first case the increased RT for both conditions was greatest on the trial following the interference, but the increase persisted for at least four more trials with all subjects in all age groups. (See Fig. I, p.170, Kaufman et al, 1973.) These results showed that in children of 5 years and under, visual RT was slowed more profoundly by the interpolation of tactual stimulation than was tactile RT by interpolation of visual. In the six year olds, both conditions were equally effective and from the age of seven onwards, interpolated visual stimulation influenced tactile more strongly than somatosensory interpolation affected visual RT (p.170).

An analysis of variance for Age X Sex X Interpolation Conditions indicated that with increasing age there was a marked shift from 'greater tactile' to 'greater visual' interpolation effects ($p < .01$). The possibility of the effects of starting a new series of RT trials being an artefact was controlled for but alternative comparisons yielded the same high level of significance and the authors therefore concluded that the fact of interpolation, and not the starting effect, was related to the increased RTs. Also these interpolation effects were shown by between 90% and 100% of the subjects. (Mode - 96%).

These results therefore permitted the inference that (1) there was a change from somatosensory to visual prepotency with increasing age, and (2) such a shift in what Kaufman calls "the hierarchical processing" occurs between the fifth and seventh years of life. It is interesting to note that Vaught et al (1975) report as follows: "Intersensory equivalence abilities are age-related and reach an asymtote around 9 years of age." (p.306).

The second procedure, viz. the 'Prestimulation' model was introduced mainly because Kaufman et al felt that in order to obtain information on the nature of the internal organisation of tactile versus visual stimulation, the two stimuli must be equated albeit subjectively. This condition they claim to have fulflled in their study, and that their results, "...permitted inferences concerning intra-modal and inter-modal functional organisation..."

The specific purpose of the design was to elicit evidence regarding the relative effectiveness of hetero- and homo-modal priming on the RTs of children of different ages. Two consecutive stimuli were given and the subjects had to respond on the second. The hetero-modal combinations were: VT and TV, and the homo-modal: VV and TT. The base-line was the prestimulation RT in each mode.

The evidence[1] derived from this model again indicated clear developmental changes in the ways in which stimulation in one sense system affects RT to a signal presented in another system. (Kaufman,

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[1] Actual results:-

Ages 3,4,5 & 6	Hetero-modal	VT/TV:	RT increased (slower) above base-line ($p < .005$)
Age 8	"	"	" : RT unchanged
Age 9	"	"	" : RT shorter ($p < .001$)
Ages 3,4,5,6 & 7	Homo-modal	VV/TT:	RT unchanged from baseline
Ages 7 & 8	"	"	" : RT slower ($p < .05$ or less)
Age 9	"	"	" : RT slightly faster but not significant

p.165): "The most general finding was a change from proximoceptive (somatosensory) to teloreceptive (visual) prepotency with increasing age."

Another noteworthy example of research generated by the dominance hypothesis of Rock and Harris, is a study by Christian Becker-Carus (1973). This author argues that even though Rock and Harris produced strong evidence to show that vision can alter tactile perception in a conflict situation, this still does not in any way negate the findings of e.g. Stratton (1897) or the experiments of Erisman and Kohler (1950), whose results point towards changes in visual perception. (Refer to page 348). Becker-Carus considers the problem to be that of finding the reasons for the different effects. These he postulates, can be found in the discrimination power of each of the two sensory systems. The author points out that under normal circumstances we are called upon to make many more visual discriminations than tactile ones, and that normally our tactile ability is not fully exploited; as can be seen when considering the achievements of schools for the blind.

In his search for an adequate explanation of the dominance phenomena shown by Rock and Harris, and by the researchers using distorting prisms, he therefore used the concept of differential sensory discrimination thresholds as the basis of his hypotheses to be tested, viz:

1. Without any previous practice, (i.e. under normal circumstances), the human adult's visual differential threshold is lower than his tactile threshold.
2. Practice will significantly lower the tactile differential threshold.

3. If the actual difference between the visual and tactual sizes of an object lies below the discrimination threshold (DV or DT) then the subject is not in fact conscious of conflict when making his size judgment of the given object, and his response will be biased in favour of whichever mode has the lower differential threshold at the time.
4. The mode used in the experimental task, VV, TT, VY or TV, would have no significant influence on the outcome.

The strategy in his two main experiments was to establish[1] a base-line differential threshold for each subject in both modes, and then to measure their matching performances over three trials in various input combinations of the two modes. Interpolated between the two experiments was a training period in which subjects were told, after each trial, the size and direction of their error in making a tactile judgment. An interesting departure in the method is the manner of presenting the conflicting stimulus material to the subjects. Aiming to eliminate both the reducing lens and the cloth as used by Rock and Harris, and others, this author wished to expose his subjects directly to both sensory stimuli without any possibility of either visual or tactile distraction.

5. The procedure was to present the subject with a standard wooden square[2] to examine visually, followed by a slightly larger block

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[1] The establishment of the DT was done as follows: the S sat at a table on which the 25x25cm block lay. With closed eyes the S had to explore this block tactually for 5 seconds. Then the S was presented with an array of seven size-graded blocks to examine. They were not to be lifted so as to prevent the relative weight differences from being used as extra information. The S then had to select a matching block to pair with the standard. Five trials were scored for each subject.

[2] Block sizes were based on pilot data, and the first standard was 20x20cm, the second, 25x25cm.

which the subject had to examine tactually with eyes closed. Before the experiment the subject is told that the two blocks are identical in size. Size judgment took the form of three matching tasks, one visually, one tactually, and the third by drawing the block. To eliminate the possibility of task order becoming an artefact, the 1st and 2nd conditions were reversed for half the subjects. In addition two control groups were tested: the first group was given the visual task only, (using the smaller block), and the second group the tactile task only, (using the larger block). All subjects executing these matching tasks had to choose a size from a standard array, using the modality in which the original stimulus was received, and then draw the size as they perceived it. After three trials the training period was interpolated.

Broadly, the results of the Becker-Carus (1973) experiments can be summarised as follows: In the case of a conflict between the information received through two sense modalities, that received from the sensory mode having the lower differential at the time, and which is therefore conducting the more reliable information, is dominant. As baseline measurements confirmed, the visual DT of a human adult is lower than his tactual DT. Consequently, if a subject receives two different perceptions of the size of an object (through two sense organs) he will choose the visually perceived size as correct. If however the tactual DT has been experimentally lowered, then the converse will pertain.

Becker-Carus claims that the results also resolve the apparent contradiction between the Rock and Harris visual dominance hypothesis and the results of the experiments with reversible lenses by e.g. Erisman and Kohler (1950).

A critical evaluation of the main studies that supported Rock and Victor's (1964) conclusion regarding visual dominance over touch was made by McDonnell and Duffett (1972) whose own study presents some further evidence that methodological problems may have produced bias in favour of vision.

Their experimental group of subjects was exposed to three sizes of standard blocks of wood perceived through both modalities, while two control groups were tested respectively through either the visual or tactile mode. After exposure to each block, subjects selected a comparison block from a size-graded array of 15 blocks. Group means[1] suggested that the experimental subjects had formed a unified impression resulting in a judgment which was a compromise between their visual and tactual impressions with an apparent bias towards the tactile modality. On closer inspection, however, subjects were shown to have made their judgments conform to either their visual or their tactile impressions, and there was a great heterogeneity of response pattern. McDonnell and Duffett fail to identify the conditions that facilitate a dominance of vision or touch, and they reject the generalisation of vision being dominant in a conflict situation, as proposed by Rock and Victor and others. They mention that there were features of Rock and Victor's 1964 study which may have favoured a predominance of vision over touch, e.g. the use of the distorting perspex cylinder and the silk cloth.

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Table III

Mean judgments of the size of the five standard blocks in inches, each mean is based on 10 judgments made by the five subjects of each group

Groups	Standard stimuli size orientation: Large side up	Large side down
EX	1.84	2.18
TC	1.53	2.49
VC	2.46	1.51

(McDonnell and Duffett (1972), p.175)

The cloth might have attenuated the tactile information, or at least encouraged the subjects to rely more on visual information.

Two years earlier, Kinney and Lurie (1972), who had also found that vision predominates over tactual and kinaesthetic information, had been similarly concerned that lenses, prisms and other distorting devices could jeopardise the subjects naïveté, and that more natural perceptual conflict conditions should be employed. They therefore looked for an instance of naturally occurring distortion, and chose to use matching tasks done above and below water. Subjects were required to match various sizes of discs with memorised sizes of common coins. Their results provided strong support for the position that visual information dominates and strongly influences other modalities. They do however concede that there is a possibility that the demand characteristics of the experiment may alert the subjects to the purposes of the study, and therefore replication of the key studies and critical evaluation of procedures is important.

Another example of a study which examines possible weaknesses is that of Butter and Björklund (1973), who note that though the majority of investigators studying visual versus haptic perception have been primarily concerned with the relative efficacy of these two modalities, and few with the specific characteristics of visual and haptic processing of information. These authors agree with Abravanel (1972) that there is a need to separate the roles of acquisition and transformation processes in the chain of information handling. Their study aims at investigating and comparing

> "...the information-gathering capabilities of the visual and haptic modalities and to equate visual and haptic information as a function of stimulus exposure. It seems plausible that the haptic system is less efficient in its gathering of information than the visual system, i.e. given equal

> exposure to a stimulus in each of these modalities, more information is obtained and therefore would be available for processing in the visual than in the haptic system." (Butter and Björklund, 1973, p.787.)

The problem of "equal exposure" is seen as being more than a matter of equal scanning time, as the time necessary for visually scanning an array of variants is not equal to that needed to explore haptically those same forms. This differential exploration time could significantly influence recognition and thus cloud possible differences between visual and haptic modalities. In order to measure the amount of information obtained by each of the two systems, these authors manipulated exposure to stimulus times in a drawing task, using accuracy of reproduction of random forms as an indication of the amount of information obtained from the exposure. Once this is known, an experimenter can vary visual and haptic exposure times and thereby eliminate a source of error. The most important result of their experiments, using adult subjects, was that "...30 seconds of one-handed haptic exposure were required before performance equalled that attained when forms were visually inspected for only two seconds." They conclude:

> "The superiority of vision over touch frequently found in vision and haptic matching studies, may well be the result of differential information obtained from equal exposures to a stimulus and not in the actual processing of that information." (p.729).

As early as 1955 Wallach and Auerbach concluded a study by stating that there are memory modalities just as there are sensory modalities. Connolly and Jones (1970), using both child[1] and adult subjects, investigated the nature of the integration between sensory modalities, notably between the visual and kinaesthetic systems, which they saw as

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[1]Three groups of children aged 5, 8, and 11, and an adult group aged 23 years.

playing a very important part in voluntary motor control. Taking due cognisance of Bryant's (1968) criticism of studies that failed to permit a distinction between intra- and cross-modality effects, and wishing to avoid the difficulties inherent in working with shapes, as Rudel and Teuber did, these authors chose tasks which involved estimating the lengths of various straight lines. Their testing technique permitted precise measures and enabled a careful control of exploratory movements to be imposed.

From an analysis of the absolute errors[1] for the four groups of subjects in both the within- and cross-modal conditions, the following can be concluded:

> "In terms of the absolute error scores the two intra-modality matching tasks are performed equally well. There is a steady decrease in the absolute error as a function of increasing age in both the intra-modal conditions. The difference in error scores is significant ($p < 0.01$; t test) between the 5- and 8-year-old groups over the four matching conditions but not between the 8-year, 11-year and adult groups.
> A striking feature of the results is the asymmetry between the cross-modal conditions. When the subjects are presented with a visual standard and required to make a kinaesthetic match, their absolute error scores are significantly greater at each age level than the reciprocal condition of making a visual match to a previously perceived kinaesthetic standard ($p \leq 0.01$; t test)."
> (Connolly and Jones, 1970, p.261).

Obtained results for the various age groups in both conditions clearly support previous investigations like that of Pick et al (1967) which concluded that perceptual discriminations become less variable

[1] Table of absolute error scores for the four groups of subjects in the intra-modal and cross-modal conditions:-

Age	Visual-Visual	Kinaesthetic-Kinaesthetic	Visual Kinaesthetic	Kinaesthetic Visual
5	1.15	1.18	2.45	1.27
8	0.82	0.86	1.87	0.97
11	0.95	0.92	1.27	1.06
A	0.72	0.69	1.23	1.01

during the course of a child's development, without this necessarily implying an increase in absolute accuracy. Connolly and Jones found that though a variance analysis reveals a somewhat different pattern, it also reveals that cross-modal translation between vision and touch is asymmetric; tactile-visual performance being significantly more accurate than visual-tactile, i.e. all the subjects in this experiment were better at forming visual equivalents of kinaesthetic models than vice versa.

In an attempt to find an explanation for the asymmetry in cross-modal functioning and for the developmental changes which have been reported, Connolly and Jones (1970) produced a model which reflects Wallach and Auerbach's (1955) statement that, "...there are memory modalities just as there are sensory modalities." This model embodies two basic assumptions:

1. That visual and kinaesthetic performance is mediated through modality-specific storage systems (as opposed to a general storage system) of which the visual system is the more efficient.
2. That the translation between the two modalities takes place prior to information being put into short-term storage.

In the case of the visual-tactile matching task, the visual information is translated into code and held in the kinaesthetic store before being reproduced kinaesthetically. Similarly, in performing a tactile task, the subject translates this signal into the visual code before forming a visual match of it. Connolly and Jones state: "The susceptibility of the kinaesthetic store to decay increases the variability of the visual-tactile performance over that of the tactile-visual performance."

Supported by evidence produced by Posner (1967)[1] this model provides a paradigm for testing the hypothesis that "translation takes place before storage in cross-modal matching."

Such a hypothesis would predict that the accuracy of the K - V task should match that obtained in the V - V task. Similarly, V - K performance should show the same properties as K - K predictions.[2]

Results substantiate this hypothesis, and Connolly and Jones summarise their conclusions by confirming that translation between modalities is performed on the basis of information held in long-term storage and which contains internal representation of the relationship between the types of information (e.g. V or K). The additional process of translation which a cross-modal match requires, serves to increase the variability of cross-modal over intra-modal performance.

Developmental changes in intra-modal performances result from improvements in the short-term storage systems, from the child's increased skill at attending to the environment and selecting the necessary information from it, and finally, from an increased efficiency in the mediating mechanism.

In view of the fact that the second aim of the present study is to consider the universality of perceptual dominance, not only across ages, but also across cultures, a study by Conners, Schuette and Goldman (1967), (the design of which was criticised by Milner and Bryant - see p.457), is also of considerable interest here.

Using information-theory methods, these authors analysed intersensory communication in children of different social class. The

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[1] Posner (1967) provided evidence to indicate that visual storage is more efficient than kinaesthetic. Given central processing capacity, he argues that the visual system functions as a 'rehearsal' mechanism, whereas the kinaesthetic store is subject to temporal decay.

[2] For diagram of the model see Appendix N , page 104

problem they selected for investigation in this study was communication of information from the haptic[1] to the visual modality.

The usefulness of the information-theory model was chosen for the greater sensitivity of the analysis to effects which would not otherwise be apparent. Essentially this advantage stems from the fact that all the information (in task responses) is evaluated, whereas otherwise discrimination tasks in which performance is recorded as error scores, fail to give partial credit for mistakes which are only slightly wrong. Also, the unit of information, the "bit", is not tied to a particular dimension, but variations between categories, e.g. size and shape could be compared.

The Conners et al study confirms previous findings that haptic-visual transfer ability follows a developmental growth function, and their results suggest that for the dimensions tested, social class is a powerful variable affecting the rate of such development. It was in fact found that social class has a marked effect on all the dimensions, (interacting in some cases with sex and age), with the lower social class children, especially the 5-year-olds, being impaired on all dimensions.

These authors also state that social class differences at such a basic level of information processing can be seen to imply that intersensory development cannot be a simple maturational process which will emerge independently of environmental effects. If children deficient in language concepts perform particularly poorly in tasks requiring intersensory communication, this would be consistent with

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[1] "Haptic" was defined here as referring to the combination of sensory impressions deriving from touch, pressure, kinaesthetic and proprioactive feedback when a subject is allowed actively to explore and feel an object.

the notion that language plays a vital role in linking information from different sense modalities.

These authors postulate that language and experience mediate cross-modal transfer.

2.3 Implications from the studies reviewed

2.31 Findings

From the studies reviewed above it seems therefore that the following findings have been well substantiated:

1. When adult subjects' sense of touch conveys information that disagrees with what they are seeing, the visual information determines their perception. This conclusion was drawn from a number of studies in which adult subjects grasped a stimulus object which they were also viewing through a distorting optic system. These objects experienced a unified impression which agreed closely with the object's illusionary visual appearance. (This effect was reflected in their responses and performance bias in matching tasks.)
2. The above conclusion is true while subjects remain unaware of the sensory conflict, but once they become aware of the distortion, expectation of unity ceases and touch is no longer dominated by vision. Hence this cognitive component, viz. the expectation of unity, is the essential element in producing a vision-touch conflict which is then resolved in the direction of the visual mode.
3. When time of exposure to the conflict was extended, size judgment did change somewhat, showing greater accuracy, but this could not be attributed to visual change. Whether objects look larger or feel smaller had still to be demonstrated. What longer exposure time did appear to demonstrate was an adaptation to "position

sense" which led to greater accuracy of judgment.

4. When the conflict was exaggerated, using reversing prisms, the results showed that vision is powerful enough to accomplish radical misperceptions by touch even in highly practised skills like writing numerals.
5. The hypothesis that more accurate and practised tactual judgment would result in less reliance on vision was not confirmed; visual dominance was not diminished by more haptic activity.
6. Cross-modal translation between vision and touch is asymmetric, tactual-visual performance being more accurate than visual-tactual. This means that subjects were better at forming visual equivalents of kinaesthetic models than vice versa. This asymmetry was attributed to the fact that translation between modalities is performed on the basis of information held in long-term storage and that the process of translation which a cross-modal match requires, serves to increase the variability of cross-modal over intra-modal performance.
7. Using interpolation as the source of conflicting sensory input, it was shown that younger children, below 9 years of age, were more susceptible to tactual interference during visual trials whereas the converse pertained for older children, who were more affected by vision during tactual trials. It was also shown that for various age-groups perceptual discrimination became less variable during the child's development, without this necessarily implying an increase in absolute accuracy.
8. Developmental changes in intra-modal performances result from improvements in the short-term storage systems, from the child's increased skill at attending to the environment and selecting the necessary information from it, and finally, from an increased

efficiency in the mediating mechanism.

9. Haptic-visual transfer ability was found to follow a developmental growth-function, and results suggest that (for the dimensions researched), social class is a powerful variable affecting the rate of such development. It was found that social class, interacting in some cases with age and sex, has a marked effect especially on 5 year-old children, with the lower social class children being impaired on all dimensions. The implication of this finding is that intersensory development cannot be a simple maturational process which will emerge independently of environmental effects. These authors also postulate that language and experience mediate cross-modal transfer.

2.32 Possible Artefacts

A number of investigators interested in explaining the sensory dominance phenomenon, have concentrated on identifying possible artefacts in existing studies in this area of research. Some of the concepts and experimental procedures which have been criticised are as follows:

1. In examining the claim that cross-modal integration increases with age, it was postulated[1] that such changes must be attributed to changes in within-modal matching, notably in the tactual modality, rather than to changes in organisation across modalities. It was argued that only if a greater improvement with age in the cross- than in the within-modal conditions was shown, could the claim for developmental improvement be substantiated. Results tabled in support show clearly that in within-modal matches the visual input

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[1] Milner and Bryant, (1968)

is more accurate than the tactual input.

2. Visual dominance has also been attributed[1] to the postulated difference between the discriminating powers of the visual and tactile systems respectively. Using this concept of differential sensory discrimination thresholds as a basis, it was hypothesised that in the case of a conflict between the information received through two sense modalities, that received from the mode having the lower differential threshold (DT) at the time, and which is therefore conducting the more reliable information, is dominant. As baseline measurements confirmed, the visual DT of an adult is lower than his tactual DT. Thus, if a subject receives two different size perceptions (through two sense organs), he will perceive the visually perceived size as correct. The converse will pertain if the tactual DT has been deliberately lowered.
3. Several authors[2] have been concerned about the possible influence of the various distorting devices like lenses, enlarging and reducing, prisms, etc., which are used to produce the conflict situation, an essential in most sensory dominance research designs. It was felt that these devices could interfere with the accuracy of tactile estimates favouring dominance of visual responses.
4. Other weaknesses that were investigated[3] were those pertaining to exposure times. These were considered in the light of the differential information-gathering capabilities attributed to the haptic and visual modalities respectively. Because of these hypothesised

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[1] Becker-Carus,(1973).

[2] McDonnell and Duffett,(1972); and Kinney and Luria,(1972).

[3] Butter and Björklund,(1973); and Abravanel,(1972).

differences, equal exposure times were claimed to favour the more efficient visual system.

5. In a critique of score assessments which take into consideration only error scores, and where no credit is given for mistakes which are only slightly wrong, a case is made[1] for the usefulness, in this respect, of the information-theory model. This method is more sensitive to effects which would not otherwise be apparent as it utilises all the information in task responses.

2.33 Explanation

Having considered all the findings and all the possible artefacts, it seems that despite many experimental and design weaknesses in past research studies, there is a considerable body of opinion that supports the notion of visual dominance as a valid concept.

Opinion varies, however, as to why tactile information differs from simultaneously received visual information. The explanation upon which some consensus has been reached is that after "sufficient exposure" to visual/tactile sensory conflict, there is a change in the sense of touch itself. (The arguments that led to this conclusion are given on p. 16.) Those who accept this explanation are in agreement that, contrary to time-honoured belief, touch does not educate vision.

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[1]Conners, Schuette and Goldman, (1967).

3. THE PRESENT STUDY

3.1 Aim and Design

The broad aim of the present study was to investigate evidence of dominance in children's cross-modal perceptual activity, and more specifically to describe a pattern of development for the dominance of vision over touch for the sensory conflict situation. The second aim was to test the cultural universality of the phenomenon and its development.

The experimental procedures of Rock and Victor (1964), which were described in detail in section 2.21, provided a basis for the design of this study. An experimental situation was created in which a subject could inspect, visually and tactually, a block placed in a box, so that its true size was felt, but which could be viewed, unknown to him, through a lens concealed in the observation aperture, which magnified the size of the image. Subjects were asked to match their impressions of the size of the block in the box, to a standard array, and in so doing were subject to a number of control and experimental conditions which are given in detail in section 3.22 below.

Rock and Victor's choice of square blocks for their standard array raised the question as to whether shape of block could possibly become an artefact in size judgment. As no alternative precedent existed it was decided to introduce both square and circular blocks into the experiment. Similarly, block size had to be carefully considered especially since in developmental studies the subjects always differ considerably in physical size. In this case hand size would determine the size limits of the blocks to be grasped, and it was decided to introduce two size-ranges designated simply as "Large" and "Small"[1] respectively, and then to check for any interaction effects.

In order to obtain data that could reflect a developmental pattern, it was necessary to test subjects separated by real differences in age, and covering an age range of at least seven years. To fulfil the second aim, these subjects had to be representative of two groups which were clearly culturally different. Each of the experimental age-groups chosen consisted of eight subjects, and each of the eight was randomly assigned to a different experimental condition. In addition to the variations of size and shape mentioned above, randomisation was extended to include alternating the two initial control tests. This additional precaution was taken to be able to determine whether or not the modality of the first exposure was significant in subsequent responses.

This randomisation meant that each of the eight members within a given age-group was presented with the tests in a way unique to him, e.g. one subject would work with Large Square blocks, commencing with Test I, whilst another would handle only Small Round blocks, possibly starting with Test II. The eight different versions are shown schematically below:

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[1]Length of one side of the square blocks or length of diameter of the round blocks: Small - 2,3, and 4 cms.
Large - 4,5, and 6 cms.

Group:	Black (Xhosa)								White							
Starting Test	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Shape:	Square		Round		Square		Round		Square		Round		Square		Round	
	Large (4,5,6 cm.)				Small (2,3,4 cm.)				Large (4,5,6 cm.)				Small (2,3,4 cm.)			
Designation:	1.1.1	2.1.1	1.2.1	2.2.1	1.1.2	2.1.2	1.2.2	2.2.2	1.1.1	2.1.1	1.2.1	2.2.1	1.1.2	2.1.2	1.2.2	2.2.2
Subject:	A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H

The essential requirement was that each subject had to make five consecutive size judgments (two control and three experimental) of a series of blocks, by choosing a matching block from a graded array of ten. A strictly sequential series of variations in the sense modalities (visual and tactual) to be used for each task was followed:

	Relative size of blocks	Sense modality used to perceive stimulus block	Sense modality used in the matching task
Test I	a	Vision	Vision
Test II	a	Touch	Touch
Test III	c	Vision & Touch	Vision
Test IV	b	Vision & Touch	Touch
Test V	a	Vision & Touch	Vision & Touch

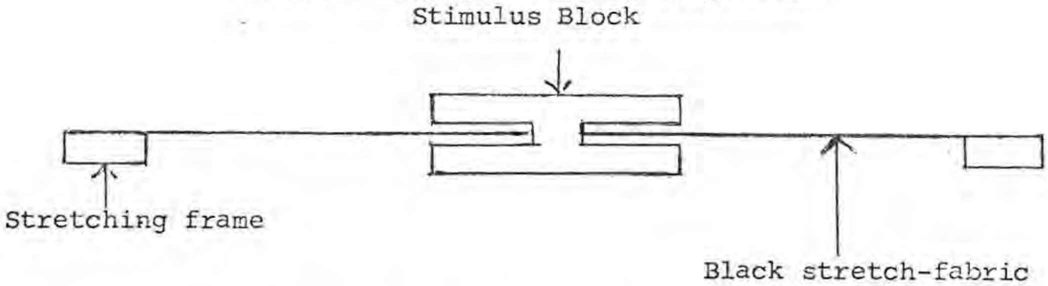
3.2 Method

3.21 Apparatus

In order to adapt Rock and Victor's apparatus to the needs of the study and to eliminate procedural errors, a pilot study was conducted. Observations made during this preliminary study emphasised the importance of ensuring that the needs of the very young subjects were carefully considered, particularly as regards communication, height and size of apparatus, and suitability of test materials.

In principle the apparatus[1] used for the main study resembled that used by Rock and Victor (1964), but two central features were different: Firstly, instead of a lens which reduced one dimension of the image by "about half", a magnifying lens which increased the total image by a factor of 2,1 was introduced. This modification was necessary to accommodate the limited span of the small hands of the very young subjects. Secondly, the stimulus blocks which in the Rock and Victor study had been tactually examined through a cloth so as to prevent the subject's fingers from being used as size cues, were redesigned as shown below.

Cross-sectional[1] view of suspension



Suspended in this way the tactual examination could now take place out of the subject's sight, i.e. below the level of the stretched fabric which supported the block. Not only did the elimination of the rather clumsy loose cloth greatly simplify the task for the small children, but it removed the possibility of an artefact arising from a textural difference being perceived when the subjects examined the block through a cloth, but not the graded array of matching blocks. The importance of the elimination of all possible visual or tactual distractions, especially when presenting conflicting stimulus material, was emphasised by Becker - Carus (1973, pages 352-3).

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[1] See Appendix B page 84 for physical dimension.

As discussed on page 27 of this study, the question of sensory dominance arising from bias produced through methodological errors, was investigated also by McDonnell and Duffett (1972), whose evidence drew attention to the problems arising from the use of conflict-producing devices.

In preparing both the stimulus blocks and the arrays of size-graded matching blocks, care was taken to obtain a very smooth finish without any marked textural peculiarities. Adequate lighting for the stimulus block also received careful attention.

Names, ages and assigned experimental designations of subjects were entered on printed scoresheets before testing was begun. For sample score sheet see Appendix D, page 86.

3.22 The Subjects

The subjects of the study were 72 Xhosa boys from 5 years to 13 years, drawn from a very depressed urban area, and 56 White boys from 5 years to 11 years. All the subjects were from Grahamstown, South Africa, either at primary, or nursery schools or at day crèches. The Black subjects were experiencing a physically, intellectually and culturally deprived childhood, whereas the Whites represented a highly privileged population group.

Groups of 8 Xhosa subjects were matched for age with groups of White subjects, these groups being spaced at yearly intervals. As these groups were to be separated by real differences in age,[1] the subjects were selected on the basis of birth dates obtained from the school registers. Subjects were not matched for levels of schooling, but as Xhosa children in the lower primary classes tend to be older

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[1]For schedule of subject ages see Appendix C, page 85.

than their White counterparts, two additional Black groups, aged 12 and 13 respectively, were included in the experiment. Hence there were 7 matched and 2 unmatched groups. In the case of the Black subjects, certain measures of preselection were applied. In addition to age and birthdate, regularity of school attendance was considered in order to ensure a measure of certainty that a planned testing session would take place at the appointed time. In choosing those pupils who were regular attenders, the more privileged and better nourished children were likely to have been chosen.

In order to eliminate transport problems, to reduce time spent by the pupils away from their classes and above all to allay the anxiety of the very young subjects, all testing was done in a hired room adjacent to the school. The subjects earned a fee for participating. A male interpreter was carefully briefed to give the standard instructions.

The White subjects were tested at their respective schools.

3.23 Experimental Procedure

As more than half the subjects had to receive their instructions through an interpreter, stringent measures were taken to keep verbal explanations to a minimum and to prevent failure of communication, especially with the very young subjects. To ensure the success of the experimental tasks, a number of very simple comprehension checks were therefore given before the main tasks were started. For details of this procedure see Appendix E , page 87ff.

Immediately after the communications check, subjects were shown how to position themselves at the apparatus, the smaller ones kneeling and the taller ones sitting on a stool resting their chins on a padded chinrest. This ensured that all subjects viewed the stimulus from a fixed distance.

At this point it is important to note that Rock and Victor (1964) had used an exposure time of 5 seconds. However the pilot study had clearly shown that this was too long a time for the younger subjects who were inclined to look up from the apparatus after about 3 seconds. So the exposure time chosen was 3 seconds. The possible effect of this change in procedure is discussed in the conclusion.

3.24 Control and Experimental Conditions

V/V: Visual stimulus alone with visual matching only

This was the visual control condition. The subject looked at the stimulus block through the magnifying system of the apparatus for three seconds. He accepted that what he was looking at was a white block against a black background and he understood that he was to match the visible block, either a disc or a square, with an array of graded size-similar blocks. This he did by pointing to the matching block without being allowed to touch it. Not only did the subject view the stimulus from a fixed distance, but the standards were kept at a constant distance from them while they made their choice. The stimulus block was of 3 cm side (or diameter) by 1 cm thick when the "Small" size range was indicated, and of 5 cm side (or diameter) when the "Large" range was required. Though the magnification factor was 2,1 a size 3 cm block was usually seen as a size 5 cm block under the V/V condition.

Half the subjects were tested on this control first and then on the tactile control. The order of the three experimental conditions was fixed in the order in which they are described.

T/T: Tactual stimulus alone with tactual matching only

After being shown how to explore the dimensions of the block through the aperture in front of the box the subject was allowed to feel the underside of the stimulus block (again 3 or 5 cm) which could normally, but not now, be viewed through the glass window in the top of the box. Three seconds active exploration of the hidden blocks was required before he was blindfolded[1] and asked to feel a sequence of blocks to choose one that matched the stimulus. Alternate subjects started from either extreme of the standard sequence so that this would not be an artefact.

VT/V: Visual and tactual stimulus with visual matching only

Here the subject performed the visual and tactual inspections simultaneously but did the matching by sight only. Care was taken to ensure that the hand was placed on the object at the moment the image was first seen. At no time could the subject see his own hand or an outline of it beneath the tautly stretched backing cloth in which the block was suspended. Blocks used here as stimuli were 2 or 4 cm squares or discs.

VT/T: Visual and tactual stimulus with tactile matching only

Again the conflicting visual and tactual stimulus was presented but matching was by touch as described for T/T. Blocks were 4 or 6 cm.

VT/VT: Visual and tactual stimulus with visual and tactile matching

Finally the simultaneous visual and tactual presentation of the stimuli was followed by a judgment in both modes together when subjects were required to feel and view the standard array.

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[1] The blindfold which is described in Appendix B was placed in a ready position, but only lowered a moment before the cover strip was lifted from the array of matching blocks. The very young subjects were given a chance to experience being blindfolded several times before the testing began.

In all five tests the cover of the viewing window was replaced after a 3-second exposure time and simultaneously the cover was removed from the standard array. This served to keep the attention of the subjects on the stimulus block, but did not prolong the interval between perception and matching.

3.25 The Dominance Index

The simplest way to estimate dominance would have been to compare the control and the experimental results directly. However, there were too many variables to make this feasible and in addition it seemed desirable to have a single score which incorporated a particular subject's collective test performance, and which was independent of the group performance. (In order to generalise from a sample to a population it is necessary to measure in the elements of the sample, i.e. in the subjects, that attribute of the elements of the population that is of interest.)

The ideal solution would have been to relate the subject's performance on each of the three experimental tasks to his performance on each of the controls, in terms of visual dominance; his score on the purely tactual control (T/T) would be scored as zero visual dominance and the visual control would be scored 100. An interval scale between these two points would then provide the desired dominance index.

Unfortunately this scale could not handle these cases in the control where the visual image was judged to be smaller than the tactile image. It was not anticipated that despite the enlarging lens such responses would be likely to emerge. Rather than resorting to the suspect procedure of discarding these observations, especially as in nearly all cases the subject's remaining responses were reasonable ones showing understanding of the task, it was decided to use, as the measures for the 0 and 100 points on the index, the modal values for the control conditions, T/T and V/V respectively.

Once these modal values in terms of raw scores had been established, a small scale of equivalents was drawn up for each block size. Hence, if e.g. a 3 cm block under the T/T control test condition yielded a response (as it usually did) of 3, it showed that there was no visual influence and this raw score was given a dominance index of 0. Similarly if this same block under the V/V control test condition yielded the raw score of 5, which was the modal figure, it showed clear visual dominance and would be given a dominance index of 100. It was then a simple matter to use these outer limits for the construction of a scale for that particular block size, viz:

Block Size:	2 cm	3 cm	4 cm	5 cm	6 cm
	2 - 0	2 - -50	4 - 0	4 - -25	6 - 0
	3 - 50	3 - 0	5 - 33,3	5 - 0	7 - 20
	4 - 100	4 - 50	6 - 66,7	6 - 25	8 - 40
	5 - 150	5 - 100	7 - 100	7 - 50	9 - 60
		6 - 150	8 - 133,3	8 - 75	10 - 80
				9 - 100	11 - 100
				10 - 125	

(See Appendix F, pages 90, 91)

This system of scaling was used to derive fully comparable dominance scores from the original matching responses. This table shows how the effect of the magnification factor and the differential size-ranges were accommodated on a common scale. Once the conversion was complete, another frequency distribution confirmed that the modes used were in fact correct. The distribution will be further described under "Discussion of results". If on this scale 0 indicates no visual influence and 100 shows strong visual dominance, then a score of about 30 is still mainly tactual but some visual influence is present, 50 equates the effects of the two modalities and higher scores show clear visual dominance. For tables of raw and converted scores for individual subjects see Appendix A, pages 66ff.

From these dominance scores, group means by ages were calculated for both Xhosa and White groups. See Table 1 below. This table contains the information necessary for the assessment of developmental trends and changes in sensory dominance over time.

The second part of the aim of the experiment could now also be fulfilled by making a test by test comparison of the individual dominance scores obtained by the 72 Black and 56 White subjects respectively. Table 2 overleaf shows this comparison which provides a basis for a conclusion about the cultural universality of the dominance phenomenon in a sensory conflict situation.

TABLE[1] 1

VISUAL DOMINANCE MEANS BY AGES

GROUP	AGE	TREATMENT				
		V/V	T/T	VT/V	VT/T	VT/VT
Xhosa	13	97	28	46	35	25
	12	122	22	67	36	56
	11	116	34	64	34	53
	10	88	25	60	42	38
	9	91	41	58	19	41
	8	91	19	23	23	34
	7	109	16	94	36	56
	6	106	44	69	83	81
	5	100	34	54	22	50
White	11	75	9	63	24	38
	10	91	19	58	13	25
	9	97	34	40	32	31
	8	66	34	65	-8	59
	7	106	22	65	23	47
	6	78	34	79	33	63
	5	97	19	88	16	78

[1] Raw and transformed scores for individual subjects displayed in Appendix A on pages 66-81.

TABLE 2

VISUAL DOMINANCE INDEX MEANS FOR BOTH GROUPS

Test Condition	Means		
	Whites	Blacks	
V/V	87	102	n.s.
T/T	25	29	n.s.
VT/V	65	59	n.s.
VT/T	19	36	less than 0,02
VT/VT	48	48	n.s.

3.3 Results

3.31 Age groups compared

Table 1 shows the means of the transformed visual dominance scores calculated for each of the nine Black and seven White age groups. These transformations are shown in detail in the Appendix, pages 66-81. This data was compiled to assess if there was any evidence of systematic developmental changes with age in sensory dominance. The figures presented here show no such pattern in either within or cross-modal performance over the two control and three experimental tasks. No signs of an age-related shift such as described by Kaufman et al (1973) page 166, were immediately evident either.

However, a careful scrutiny was made of the age groups that registered the extreme scores in each test and an interesting though not unexpected trend emerged. From the table below, it will be seen that when looking across the five tests for both cultural groups, in nine out of the ten cases, the highest scoring age groups included children who were 5, 6, or 7 years of age.

This trend suggests that the lowest visual dominance means might therefore have been produced by the older age groups. It was found that in all except one test, viz. the V/V test with Black subjects, the lowest scorers were indeed older than the high scorers, but in only three cases were these scores produced by the oldest subjects. (See Xhosa group in Test VT/VT and White group in Tests V/V and T/T.) The rest were scattered irregularly between the ages of 7 and 13. This position is summarised below, the numbers in the brackets giving the age group which produced the score:

Group	Test	Highest /	Lowest Vis.Dom. Means	Group mean
Xhosa	V/V	122 (12)	88 (10)	102
	T/T	44 (6)	16 (7)	29
	VT/V	94 (7)	23 (8)	59
	VT/T	83 (6)	19 (9)	36
	VT/VT	81 (6)	25 (13)	48
White	V/V	106 (7)	75 (11)	87
	T/T	34(6,8,9)	9 (11)	25
	VT/V	88 (5)	40 (9)	65
	VT/T	33 (6)	-8 (8)	36
	VT/VT	78 (5)	25 (10)	48

This developmental trend suggested by the extreme scores, is not sustained with any degree of consistency by the intermediate scores and therefore no age-related development or hierarchical shift could be found in any of the within or cross-modal test results. A careful examination of the frequency tables showing the collected visual dominance scores for each age-group in each task (see pages 92 - 96 of Appendix G) revealed no single age group which consistently deviated markedly from the predicted ideal modal score. Hence no clear differences could be found in the sensory dominance scores of the various age groups.

3.32 Xhosa and White children compared

Table 2 shows a comparison, test by test, of the visual dominance index means for the Xhosa and White groups. This comparison was made to evaluate the cultural universality of the phenomenon of visual dominance over touch in a sensory conflict situation. In reporting the results of each test situation in turn, the figures quoted will be from the above-mentioned table and from the set of frequency distribution tables displayed in the Appendix from pages

V/V: Here subjects viewed the block, through the lens, without touching it so the score corresponds with a purely visual matching. As only the visual modality was involved, and visual dominance would be complete, modal responses were scored as 100. (In this case raw modal values 9 or 5 = 100.)

Out of 72 Black subjects, 38 gave this response, the rest of the scores being widely dispersed in both directions from the mode. Though the mode was the same for the White group, only 19 subjects gave this response. Two out of three of the rest chose a block smaller than the theoretical ideal. The resultant lowered mean of 87 is further away from the theoretical ideal than that of the Xhosa group, 102. Both groups showed a wide scatter of scores; up to 6 scale points on both sides of the mean being used by the 5 to 8 age groups.

T/T: Here the subjects held the block and then felt for the matching sample. No vision is involved, so ideally the scores for T/T, a purely tactual match, should be zero. In this task, both distributions were less scattered. Black scores showed more errors as only 23 subjects scored 0, and 22 scored 50, i.e. two scale points from the ideal mode. Of the rest 17 scored 25, one scale point higher. In the White group more than 50% gave the modal response and the rest were 1 to 2 scale points higher. Apart from these examples, no further clustering of scores was shown. The difference between the group means was not significant.

VT/V: Here the sensory conflict was introduced for the first time. The block was touched and viewed, but matching required was visual only. Theoretically the mode would be about 70. Both groups produced very similar scores, 50 being the mode. However the group means rose to around 60 as 9 Black subjects and 14 Whites scored 100. Again there was no significant difference between the means, but this result masked the heterogeneity of the distribution.

VT/T: Here the conflict situation was that the stimulus block used was touched and viewed but matching was done by touch alone. This test yielded visual dominance indices for the Black group which ranged from -20 to 167 with a mode of 33,3, very close to the predicted mode of "around 30". The White group produced another bimodal distribution with two groups of 15 subjects scoring 0 and 33,3 respectively. Here nearly one half of the Blacks showed a visual dominance score in excess of the ideal of 30. Black and White mean differences reached a significance of less than 0,02.

VT/VT: Here both modalities were involved in the stimulus and in the matching process, and in terms of means, both groups came very close to the hypothesised half-way mark. In both Black and White groups the modal score of 50 clearly predominated and both groups produced mean dominance index scores of 50. However, the frequency distribution once again shows that of those beyond the modal score, 28 Blacks and 20 Whites showed a bias in the tactile direction, while only half this number showed marked visual dominance. Again, both groups were more affected by the tactile influence than by visual dominance.

3.4 Possible Artefacts

Before considering these numerical results in further detail and drawing conclusions from them, it is necessary to report on the steps taken at the outset to ensure that the recorded responses in this experiment could not have been artefacts of the experimental design, and that the sets of subjects to be compared across cultures were indeed sufficiently homogeneous to be fully comparable.

In testing the effects of the variables which had been introduced into the research design, e.g. stimulus block variations and the alternating of the V/V and T/T controls, raw scores were used. As these responses were not discrete, they had to be reduced to ranks, and a non-parametric test designed for an ordinal level of measurement, viz. the Mann-Whitney U-Test, was applied.

The first of these tests controlled for the possible effect of shape of stimulus block, i.e. those subjects who judged square blocks were compared with those who judged round blocks. Hence within each of the tests, subjects were compared if their test conditions were identical except for this one feature - viz. shape of block, (denoted by the second digit in the code), e.g.

1.1.1 vs. 1.2.1 (Large square blocks vs. Large round blocks).

and 2.1.1 vs. 2.2.1 (Small square blocks vs. Small round blocks).

all starting with the V/V control.

also 1.1.2 vs. 1.2.2 (Large square blocks vs. Large round blocks).
and 2.1.2 vs. 2.2.2 (Small square blocks vs. Small round blocks).
but all starting with the T/T control.

This procedure was followed for White and Black subjects respectively. For results see Table (Appendix H, page 97).

Next, the possible influence of the test order was checked by making test by test comparisons between subjects who started with control V/V and those who had started with control T/T, (denoted by the first digit in the code), e.g.

The 1.1.1 subjects vs. 2.1.1
and 1.2.1 subjects vs. 2.2.1
also 1.1.2 subjects vs. 2.1.2
and 1.2.2 subjects vs. 2.2.2

For Black and White Ss respectively.

For results see Table (Appendix J, page 99).

As the introduction of two size ranges of stimulus blocks had resulted in responses which themselves fell into a double set of high and low figures, it was not feasible to use the same statistical technique to control for this variable. This data was therefore subjected to an analysis of variance. The technique selected was the Kruskal-Wallis one-way analysis of variance. It was made (test by test) between sets of four subjects, e.g.

Sets 1.1.1, 1.2.1, 2.1.1, and 2.2.1

and Sets 1.1.2, 1.2.1, 2.1.2, and 2.2.2

respectively were subjected to the analysis of variance. (See Table Appendix K, page 101).

As no significant differences were revealed by these tests, neither variations of size and shape in the stimulus blocks, nor the test order followed, could be considered as artefacts influencing the outcome of the experiment.

Finally a cross-cultural comparison of each of the 5 tests, given under the 8 different conditions was made, again using the Mann-Whitney test. This means that Black (Xhosa) and White groups were compared on all dimensions and no significant differences emerged except that in test V/V the 1.1.1 groups were shown to differ at the .05 level of significance, and groups 1.1.2 at the .02 level. Hence, out of 40 comparisons, only 2 showed any significance. The sets of subjects used in this experiment could therefore be considered to be homogeneous. See Appendix L, page 102.

3.5 Discussion of the results and conclusions

3.51 Analysis of results of age group comparisons

The results presented in Table 1 on page , viz: the "Visual dominance means by ages" for both Xhosa and White subjects, and which failed to show any clear evidence of developmental changes between age groups, are characterised by numerous anomalies.

In both cultural groups, visual dominance mean scores of adjacent age-groups were frequently widely divergent, or conversely, in several instances identical, or near-identical scores were registered by widely differing age-groups. Thus e.g., in Test T/T, Black 11 and 5 year-olds share a common mean score of 34, while in Test TV/V the highest and lowest means were scored by 7 and 8 year-olds respectively, viz. 94 and 23. These anomalies refuted the existence of any hierarchical, age-related changes in these scores. This failure to find a clear developmental trend confirms the findings of Rudel and Teuber (1964) as quoted by Milner and Bryant (1968).

Kaufman et al (1973) claim that a clear shift in sensory interaction takes place between the fifth and the seventh year of life. The present study confirmed that the 5, 6, and 7 year-old subjects produced extreme scores in nine out of ten instances. A close scrutiny of the frequency distribution tables displayed in Appendix G1-G5, pages 92-96, shows quite plainly that the younger subjects (5, 6, and 7), showed a higher incidence of extreme values, on both sides of the modal position, than did the older subjects (11, 12, and 13). This means that their scores occupied a greater number of scale intervals than those of the older children. Their scores had a strong central tendency. (See table of scale spaces occupied in Appendix M, page 104).

These qualitative differences which are not revealed in the mean scores, reflect a cognitive immaturity commensurate with their ages. It was noted by the examiner that during size judgment practice in the initial communications check, that an array of only 5 size-graded items was seen by the pre-school and other very young children as a dichotomy of sizes which they verbally labelled as "big" or "small" respectively. It is therefore reasonable to suggest that for these children the finer discrimination required when faced with an array of 10 standard blocks, could easily result in poor size matching. If two blocks, e.g. 8 and 9, both seen as "big" were arbitrarily chosen, a dominance score difference of between 20 and 25 would be registered. It is therefore clear that any such guessing would be reflected in wider score distributions such as those shown in these frequency tables. It is interesting to note that in the purely tactile task, where this type of dichotomising cannot be applied, the extreme limits of the dominance index scale were exceeded by only 4 out of 128 subjects.

The qualitative differences in the performances of the younger children seem not to be in their sensory interaction but rather in their matching task approach where age-related cognitive incompetence could be the reason. If it were the former, the direction of their bias would be opposite to that of the older children.

In the search for a pattern of development for the dominance of vision over touch for the sensory conflict situation, it is of interest to consider the work of Kaufman et al[1] (1973). Though not actually dealing with conflicting sensory information, it was nevertheless concerned with the interaction of the tactile and visual sense systems. Their work is of particular relevance here because their subjects were also young children (3 to 9 years). This developmental study using reaction-time models, tested children in a set of trials in one mode followed by a period of stimulation in the other mode. This was followed by a second set of trials in the original mode. Younger children were found to be more susceptible to the tactual interpolation during the vision trial than were the older ones, who were more affected by visual stimulation during the tactual trials. They concluded that there was a change from somatosensory to visual prepotency with increasing age. This finding was not confirmed by the present study where evidence of bias was only rarely shown by the younger subjects alone. (See Test VT/T.) Usually deviations from the mode were similar in direction for all ages. When the younger subjects did show sharp deviations from the mode, these scores were usually spread quite widely in both directions alike.

Although no systematic difference in the performances of younger

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[1] See review of research literature, section 2.22, page 21.

and older children on the size judgment tasks under conflicting sensory conditions were found, it will be seen from the tabulated results (Table 1 and the Frequency distrubution tables), that the overall performance of the children of the age tested, is markedly different from that reported previously for adults. This will be shown in detail below. Although the development of sensory dominance, as shown in this study differs from the sensory interaction shown by Kaufman et al (1973), this does not mean that the difference in visual dominance displayed in this study cannot now be attributed to the fact that these subjects were children, as opposed to adults.

3.52 Discussion of results of comparison of Black and White Subjects

V/V: In this purely visual task, where all subjects could theoretically have been expected to choose a block yielding a dominance score of 100, differences between the means of the Xhosa and the White scores did no more than approach statistical significance. A larger difference than that might have raised the question of whether the apparently more accurate Black judgment could not have been a contrast to the performance of White subjects whose familiarity with magnifying glasses revealed to them the otherwise concealed deception. In this connection it is interesting to note that throughout the experiment only one subject, a 10 year-old White subject, showed that he had become aware of the conflict situation, by asking: "Which one must I match, the big one or the small one?"

T/T: The Black subjects made more errors of tactile judgment, as seen in the bi-modal distribution of scores. Less than one third (23) of the subjects chose the mode, 0, and 22 chose two block sizes larger than the stimulus block. These errors accounted for the difference between the Black and White means of 29 and 25 respectively. The greater competence of the White children at making tactile size judgments can at least partially be ascribed to their familiarity with blocks and construction sets. Black children rarely have such toys.

VT/V: These results can be compared with those of Rock and Victor (1964). To do this, their scores,[1] (Rock and Victor (1964), page 595, column 2), were transformed into dominance indices, using the same scale as before. For the experimental test VY/V the mean score was 93, considerably above the scores of the present study where both groups showed only a small visual dominance. The mode was well below the predicted ideal. It would be plausible to suggest that this difference can be explained by the fact that the comparison was between adults and children, but whether the children's different performance reflects a true difference or not will be discussed below.

VT/T: Here the overall mode of 33,3 equalled the predicted theoretical mode, but the individual age group results reflect a very strong tactual bias. 24 White subjects scored one or two visual dominance scale points below this ideal figure. These subjects therefore reacted as if the task was purely tactile and no visual conflict had been introduced. In the Black group more than a third of the subjects gave responses of 0 to 20. Only ten White subjects scored in the direction of greater visual influence, but almost a third (21) of the Black children did so. Of these 14 reached the predicted score for the VT/V condition. Hence this time the Xhosa children were less

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[1] Rock and Victor (1964), page 595: "The mean (N=10) for the experimental condition (VT/V) was a width of 14.1 mm; for vision alone the mean width obtained was 13.4 mm; and for touch alone the mean width was 23.1 mm." It must be remembered that here the lens was a reducing one, hence the larger dimension for touch alone.

influenced by touch, the difference being significant at the .02 level. The younger White subjects showed a heavy bias towards the tactual mode.

Once more the Rock and Victor scores were translated and used for comparison. Here they yielded a dminance index of 94, and they report complete dominance of vision over touch even for touch matching. In this context it will be recalled that Rock and Victor maintained: "It could also be argued that it should not make any difference what comparison technique was used, since the subject received a unitary impression and would communicate this impression by whatever type of comparison he made."

VT/VT: The shared group mean score of 48 shows that Black and White children performed equally and chose a size match showing equal contributions from vision and touch. This is different from the adult performance cited above, but consistent with the remaining results of the present study.

The difference becomes even more clear when examining the individual group scores for this test condition (see Appendix G, page 93ff.) Here it will be seen that in fact more than one third of the 128 subjects showed a tactile bias below the modal score of 50. Of those who did show some visual influence the majority were Black, emphasising again that the White subjects tended to use their tactual information at the cost of their visual impressions; not so the Black subjects.

Looking now at the whole pattern of results in Table 2, the following may be concluded:

1. When children are presented with conflicting visual and tactual data about the size of an object of which they have a unitary impression, then touch and vision contribute equally to their size judgments, provided both senses are active in these judgments. When

vision alone is active, then the judgment is biased towards vision, but only to a small degree. When touch is the mode of judgment, then bias is heavily toward the tactile mode.

2. If Xhosa and White children perform these judgments then their behaviour is similar, except in the case of the tactual judgments (T/T and VT/T). Here the Black children were significantly less influenced by touch than their White counterparts.

4. IMPLICATIONS AND DISCUSSION

Before it can be accepted that the performances obtained in this study, and which differ from those of other studies, do reflect a true difference in visual dominance, it is necessary to examine the possibility that this is due to changes made in the method.

The first of these changes concerns the optical system which was not that of the previous work. Nevertheless, the visual dominance indices it produced, were comparable in magnitude to those produced by a variety of optical distortions devised to create a conflict situation. As emphasised by Miller (1972), the overwhelming importance lies in creating the expectation of congruent tactual and visual information and any mechanical variations and digressions are probably not important.

Judging by their verbal behaviour, less than one per cent of the children tested became aware of the optic device. When this happens, the expectation of unity ceases and touch is no longer dominated by vision. These subjects were less dominated by vision but the effect did not disappear as would have happened if the conflict had been removed.

However the possibility that especially the very young children might not have received a unitary impression and had been unable to express this, cannot be ignored. Looking at the results of e.g. VT/VT, where equal effects of touch and vision were given, it can be assumed that the children were "aware" of two sets of information but nonetheless were able, because children have a higher tolerance of ambiguity, to accommodate this awareness in the demand for a unitary response.

Such a state of affairs does not deny the central role of the cognitive element of the task and can in fact use the cognitive development of the child as the vehicle to convey change in sensory dominance. It seems therefore that the conclusions given can stand, especially as there are sufficient similarities in the Xhosa and White scores to permit denial that the one exception reported is due to Xhosas not understanding the task in the same way as the Whites.

The second change was the exposure time of 3 seconds, which differed from that of Rock and Victor. In a study by Butter and Björklund (1973), who were investigating the roles of acquisition and transformation processes in cross-modal perception, these authors emphasise that the time necessary for haptic exploration should be considerably longer than that allowed for visual scanning as "...30 seconds of one-handed haptic exposure were required before performance equalled that attained when forms were visually inspected for only two seconds..." They also suggest that the superiority of vision over touch frequently found in vision and haptic matching studies may well be the result of differential information obtained from equal exposure to a stimulus and not to the actual processing of that information. (Page 729. For full review see page 28 .)

If this were the case in the present study, there should be an overwhelming bias towards visual dominance. Instead the converse is true. The direction of these results therefore precludes the possibility of the bias being due to the shorter exposure time.

Summary

This investigation was made in response to the claims by Rock and Victor (1964), Rock and Harris (1967) and others, that in adults sight dominates touch in all situations of sensory conflict and that sight is primary in development in that sight shapes touch. The experiment was designed to test:

1. Whether this was so for children in the case of size judgment, and

2. whether this holds for other cultures such as Xhosa children living in South Africa, whose size judgments are not practiced to the degree imposed by western cultures.

Conclusions

After an analysis of the whole sample, and having duly considered all the evidence presented in the form of tables and results, verbal descriptions and discussion, it now seems reasonable to conclude as follows:

1. For children, touch and vision contribute equally to the resolution of sensory conflict when both senses are active in size-judgments, and when only one mode is allowed for judging, then the resolution is biased towards this mode.

2. The performance of the children of this study is different to that of the adults of Rock and his co-workers' studies in that adults are dominated completely by vision in a sensory conflict situation.

3. The findings of this study appear culturally universal.

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 13 years
N = 8

TREATMENT			V/V		T/T		VT/V		VT/T		VT/VT	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index[1]	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	164	L	9	100	5	0	5	33.3	6	0	6	25
B	163	S	6	150	4	50	3	50	6	66.7	3	0
C	166	S	5	100	4	50	3	50	4	0	3	0
D	164	L	7	50	6	25	6	66.7	7	20	8	75
E	162	S	5	100	4	50	3	50	6	66.7	4	0
F	165	S	5	100	4	50	3	50	6	66.7	4	0
G	163	L	8	75	5	0	6	66.7	8	40	8	75
H	164	L	9	100	5	0	4	0	7	20	6	25
Σ :				775		225		366.7		280		200
$\bar{X}$:				96.88		28.13		45.84		35.00		25
SD :				28.15		24.78		21.37		29.13		32.73

[1] Transformation of raw scores to visual dominance indices according to description on page 90 of text.

APPENDIX A.1

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 12 years
N = 8

TREATMENT			V/V		T/T		VT/V		VT/T		VT/VT	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	148	S	6	150	4	50	4	100	6	66.7	5	100
B	154	S	5	100	3	0	2	0	4	0	3	0
C	153	S	5	100	3	0	2	0	5	33.3	4	50
D	148	S	6	150	4	50	4	100	6	66.7	5	100
E	153	L	9	100	6	25	6	66.6	8	40	7	50
F	148	L	9	100	5	0	6	66.6	7	20	8	75
G	153	L	10	125	6	25	7	100	6	0	5	0
H	149	L	11	150	6	25	7	100	9	60	8	75
Σ :				975		175		533.3		286.7		450
$\bar{X}$:				121.88		21.88		66.66		35.84		56.25
SD :				24.78		20.86		43.64		27.60		39.53

APPENDIX A.3

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 11 years

N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	141	L	9	100	6	25	7	100	9	60	5	0
B	136	L	7	50	6	25	5	33.3	7	20	6	25
C	142	S	6	150	4	50	3	50	5	33.3	5	100
D	142	S	5	100	4	50	3	50	4	0	3	0
E	136	L	9	100	6	25	5	33.3	7	20	6	25
F	136	L	10	125	5	0	7	100	8	40	10	125
G	141	S	5	100	4	50	3	50	5	33.3	4	50
H	141	S	7	200	4	50	4	100	6	66.7	5	100
Σ :				925		275		516.6		273.3		425
$\bar{X}$:				115.63		34.38		64.58		34.16		53.13
SD :				44.9		18.60		30.14		21.81		48.99

APPENDIX A.4

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 10 years
N = 8

TREATMENT			V/$_V$		T/$_T$		VT/$_V$		VT/$_T$		VT/$_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	130	L	8	75	5	0	6	66.7	7	20	5	0
B	123	L	9	100	6	25	6	66.7	9	60	7	50
C	129	L	9	100	6	25	6	66.7	7	20	6	25
D	129	L	8	75	5	0	5	33.3	8	40	6	25
E	124	S	5	100	5	100	4	100	8	133.3	5	100
F	129	S	6	150	2	-50	3	50	5	33.3	4	50
G	124	S	5	100	5	100	3	50	4	0	3	0
H	125	S	3	0	3	0	3	50	5	33.3	4	50
Σ :				700		200		483.2		340		300
$\bar{X}$:				87.5		25		60.4		42.5		37.5
SD :				42.26		51.75		19.80		40.61		32.73

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 9 years
N = 8

TREATMENT			V/$_V$		T/$_T$		VT/$_V$		VT/$_T$		VT/$_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	112	L	9	100	5	0	5	33.3	7	20	6	25
B	112	L	9	100	6	25	5	33.3	6	0	6	25
C	112	L	8	75	6	25	6	66.7	7	20	6	25
D	112	L	7	50	6	25	5	33.3	5	-20	7	50
E	111	S	5	100	4	50	3	50	5	33.3	4	50
F	117	S	5	100	4	50	3	50	5	33.3	3	0
G	116	S	5	100	5	100	5	150	5	33.3	5	100
H	112	S	5	100	4	50	3	50	5	33.3	4	50
Σ :				725		325		466.7		153.2		325
$\bar{X}$:				90.63		40.63		58.34		19.15		40.63
SD :				18.60		29.69		38.84		19.65		29.69

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 8 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	106	L	5	0	5	0	4	0	6	0	5	0
B	98	L	9	100	4	-25	4	0	7	20	5	0
C	102	L	10	125	6	25	5	33.3	5	-20	5	0
D	97	L	7	50	5	0	4	0	7	20	6	25
E	99	S	7	200	3	0	3	50	3	-33.3	4	50
F	99	S	2	-50	4	50	2	0	6	66.7	4	50
G	100	S	5	100	4	50	3	50	6	66.7	5	100
H	100	S	7	200	4	50	3	50	6	66.7	4	50
Σ :				725		150		183.3		186.8		275
$\bar{X}$:				90.63		18.75		22.91		23.35		34.38
SD :				88.58		29.12		25.10		40.17		35.20

APPENDIX A.7

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 7 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	94	L	8	75	6	25	6	66.7	7	20	7	50
B	93	L	8	75	5	0	8	133.3	9	60	8	75
C	95	L	8	75	8	75	8	133.3	8	40	9	100
D	94	L	9	100	4	-25	6	66.7	6	0	6	25
E	94	S	6	150	3	0	4	100	4	0	3	0
F	94	S	5	100	4	50	5	150	6	66.7	5	100
G	94	S	7	200	3	0	3	50	6	66.7	4	50
H	95	S	5	100	3	0	3	50	5	33.3	4	50
Σ :				875		125		750		286.7		450
$\bar{X}$:				109.36		15.63		93.75		35.84		56.25
SD :				44.19		32.56		40.75		27.60		34.72

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 6 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	84	S	6	150	5	100	5	150	5	33.3	5	100
B	84	L	7	50	5	0	5	33.3	6	66.7	6	25
C	84	L	11	150	7	50	6	66.7	9	166.7	8	75
D	84	L	9	100	5	0	6	66.7	9	166.7	7	50
E	84	S	8	250	3	0	3	50	5	33.3	6	150
F	83	S	5	100	5	100	5	150	6	66.7	6	150
G	83.5	L	7	50	5	0	5	33.3	6	66.7	7	50
H	83	S	3	0	5	100	2	0	6	66.7	4	50
Σ :				850		350		550		666.8		650
$\bar{X}$:				106.25		43.75		68.75		83.35		81.25
SD :				77.63		49.55		54.51		53.47		47.72

APPENDIX A.9

VISUAL DOMINANCE SCORES

Group: BLACK
Age: 5 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	77	L	9	100	5	0	5	33.3	6	0	6	25
B	76	L	9	100	6	25	6	66.7	6	0	8	75
C	76	S	5	100	4	50	3	50	5	33.3	4	50
D	76	S	5	100	4	50	3	50	5	33.3	4	50
E	63	L	9	100	6	25	6	66.7	7	20	7	50
F	63	L	9	100	6	25	6	66.7	7	20	7	50
G	63	S	5	100	4	50	3	50	5	33.3	4	50
H	64	S	5	100	4	50	3	50	5	33.3	4	50
Σ :				800		275		433.3		173.3		400
$\bar{X}$:				100		34.38		54.16		21.65		50
SD :				0		18.60		11.81		14.57		13.36

APPENDIX A.10

VISUAL DOMINANCE SCORES

Group: WHITE
Age: 11 years
N = 8

TREATMENT			V/V		T/T		VT/V		VT/T		VT/VT	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	136	L	8	75	5	0	6	66.7	7	20	7	50
B	131	L	9	100	5	0	6	66.7	8	40	7	50
C	132	L	7	50	5	0	5	33.3	6	0	5	0
D	137	L	10	125	6	25	5	33.3	6	0	7	50
E	134	S	4	50	4	50	2	0	5	33.3	4	50
F	133	S	5	100	3	0	3	50	6	66.7	3	0
G	130	S	4	50	3	0	3	50	4	0	4	50
H	130	S	4	50	3	0	6	200	5	33.3	4	50
Σ :				600		75		500		193.3		300
$\bar{X}$:				75		9.375		62.50		24.162		37.5
SD :				29.88		18.60		59.60		23.89		23.145

APPENDIX A.11

VISUAL DOMINANCE SCORES

Group: WHITE
Age: 10 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	122	L	8	75	5	0	4	0	7	20	5	0
B	124	L	8	75	5	0	9	166.7	5	-20	6	25
C	119	S	5	100	4	50	3	50	5	33.3	4	50
D	120	L	7	50	5	0	5	33.3	6	0	5	0
E	120	S	5	100	3	0	3	50	4	0	3	0
F	119	S	5	100	4	50	3	50	5	33.3	4	50
G	124	L	10	125	5	0	6	66.7	6	0	6	25
H	119	S	5	100	4	50	3	50	5	33.3	4	50
Σ :				725		150		466.7		100		200
$\bar{X}$:				90.63		18.75		58.34		12.49		25
SD :				22.90		25.88		47.99		20.28		23.15

VISUAL DOMINANCE SCORES

Group: WHITE
Age: 9 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	111	L	8	75	6	25	6	66.7	8	40	7	50
B	111	S	6	150	3	0	3	50	5	33.3	4	50
C	109	L	10	125	6	25	5	33.3	6	0	5	0
D	110	L	8	75	5	0	5	33.3	7	20	6	25
E	108	S	4	50	4	50	3	50	5	33.3	3	0
F	108	L	9	100	6	25	5	33.3	9	60	6	25
G	107	S	5	100	5	100	2	0	5	33.3	4	50
H	106	S	5	100	4	50	3	50	5	33.3	4	50
Σ :				775		275		316.7		253.3		250
$\overline{X}$:				96.88		34.38		39.58		31.66		31.25
SD :				31.16		32.56		19.81		16.99		22.16

APPENDIX A.12

VISUAL DOMINANCE SCORES

Group: WHITE
Age: 8 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT_{/VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	102	L	9	100	7	50	7	100	8	40	8	75
B	105	L	6	25	5	0	7	100	6	0	5	0
C	101	L	6	25	8	75	5	33.3	5	-20	6	25
D	100	L	6	25	5	0	5	33.3	6	0	6	25
E	99	S	5	100	4	50	4	100	4	-40	6	150
F	92	S	5	100	3	0	3	50	6	0	3	0
G	97	S	4	50	4	50	3	50	5	-20	4	50
H	99	S	5	100	4	50	3	50	5	-20	6	150
Σ :				525		275		516.6		-60		475
$\overline{X}$:				65.63		34.38		64.58		-7.50		59.38
SD :				37.65		29.69		30.14		23.75		61.15

VISUAL DOMINANCE SCORES

Group: WHITE
Age: 7 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	92	L	7	50	5	0	7	100	6	0	5	0
B	95	L	9	100	5	0	6	66.7	7	20	7	50
C	91	S	6	150	3	0	3	50	4	0	4	50
D	94	S	5	100	3	0	3	50.	4	0	4	50
E	94	L	10	125	5	0	5	33.3	10	80	6	25
F	94	S	5	100	4	50	3	50	5	33.3	4	50
G	93	S	5	100	5	100	4	100	5	33.3	5	100
H	93	L	10	125	6	25	6	66.7	7	20	7	50
Σ :				850		175		516.7		186.6		375
$\bar{X}$:				106.25		21.88		64.58		23.33		46.88
SD :				29.12		36.44		24.30		26.90		28.15

APPENDIX A.15

VISUAL DOMINANCE SCORES

Group: WHITE
Age: 6 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	84	S	6	150	4	50	4	100	5	33.3	4	50
B	82	S	4	50	3	0	3	50	5	33.3	5	100
C	76	L	8	75	5	0		33.3	5	-20	5	0
D	81	S	5	100	5	100	4	100	6	66.7	5	100
E	78	S	4	50	4	50	3	50	5	33.3	4	50
F	84	L	8	75	6	25	8	133.3	10	80	9	100
G	80	L	7	50	5	0	6	66.7	7	20	7	50
H	76	L	8	75	7	50	7	100	7	20	7	50
Σ :				625		275		633.3		266.6		500
$\bar{X}$:				78.13		34.38		79.16		33.33		62.50
SD :				33.91		35.20		34.21		30.45		35.36

APPENDIX A.16

VISUAL DOMINANCE SCORES

Group: WHITE
Age: 5 years
N = 8

TREATMENT			$V/_V$		$T/_T$		$VT/_V$		$VT/_T$		$VT/_{VT}$	
S.	Age in months	Block Size Large/ Small	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index	Raw Score	Dom. Index
A	65	L	7	50	5	0	5	33.3	7	20	4	-25
B	64	S	7	200	3	0	4	100	6	66.7	5	100
C	68	S	7	200	3	0	4	100	4	0	5	100
D	62	L	11	150	5	0	7	100	7	20	9	100
E	62	L	8	75	8	75	7	100	6	0	9	100
F	70	S	5	100	3	0	4	100	5	33.3	6	150
G	65	L	5	0	4	-25	6	66.7	7	20	5	0
H	61	S	3	0	5	100	4	100	3	-33.3	5	100
Σ :				775		150		700		126.7		625
$\bar{X}$:				96.88		18.75		87.5		15.84		78.13
SD :				80.66		43.81		24.81		28.93		58.92

APPARATUS

A. For list of items required for the preliminary communication check, see "Notes to Interpreter", Appendix E , page 87 .

B. Apparatus used in the sensory dominance experiment.

1. Items required to produce conflicting sensory information:

1.1 A box which housed the optical system responsible for the visual distortion. (See sketch on page 83 for physical dimensions.)

1.2 A padded chin-rest to keep subjects at a standard distance from the stimulus point.

1.3 An elasticised blindfold - made of black cotton fabric.

1.4 A set of 10 white stimulus blocks, 5 square and 5 circular; their sides (or diameters) ranging from 2cm to 6cm. They were mounted as follows: Each block consisted of two identical pieces of wood 1cm thick, either square or disc shaped, which are joined (horizontally) at their centres to leave a gap of 2mm between them. Each block is then suspended in the centre of a square of black elasticised fabric, (stretched tightly over a frame), by passing one half of the block through a small slit in the centre of the fabric. (The 2mm gap between the two halves of the block allows the fabric to close tightly around the connecting rod.) The block was thus firmly but not rigidly held in position. This arrangement allows horizontal movement, but inhibits excessive vertical movement which could easily betray the presence of the reducing lens. The subjects could see that they were in fact moving the block that they were viewing, but no cues could be taken from their fingers which were concealed below the stretched fabric. The matt surface of stretch-fabric further reduced possible visual cues. In appearance the exposed half of the stimulus block will match exactly its equivalent in the standard array described in 2.1 below.

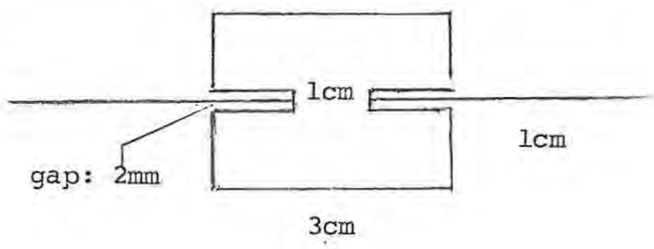
2. Standard blocks required in the matching tasks:

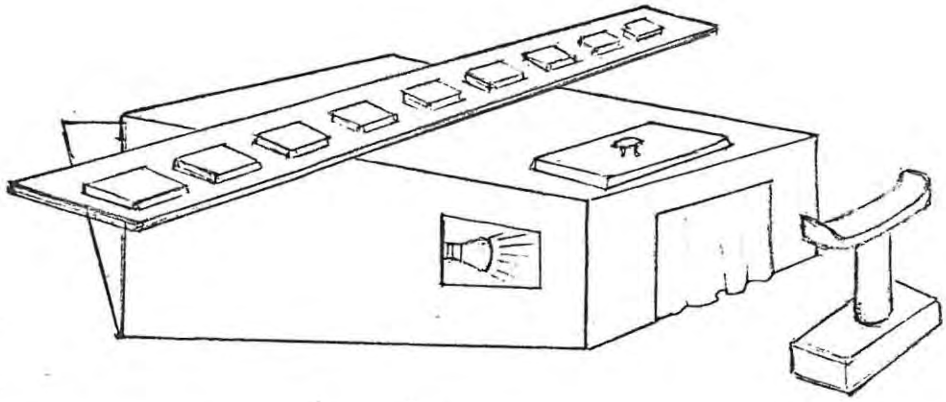
2.1 Two standard arrays each of 10 graded blocks (squares or discs) ranging in size from 2cm sides (or diameter) to 11cm by 1cm thick. To facilitate tactile examination, each block is raised by 3cm from the backboard by mounting it on a stem. Cork or rubber bottle stoppers were found to be suitable for this purpose. (See illustration on page 84.)

2.2 An additional lightweight board to be used as a cover for the standard arrays.

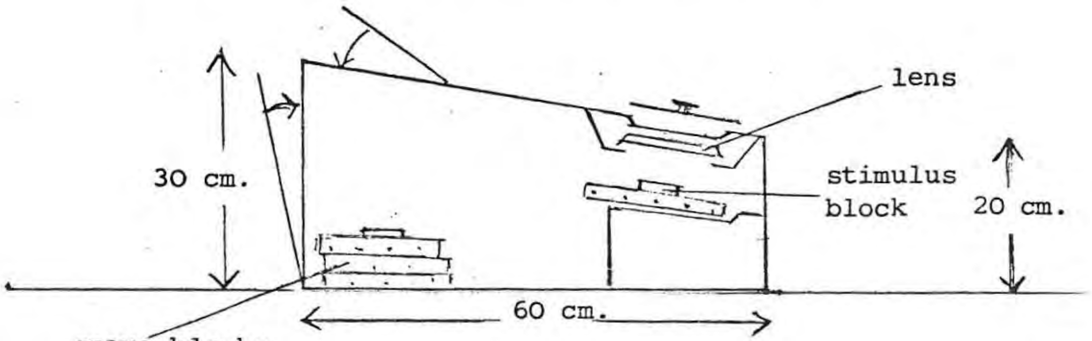
2.3 A stock of printed scoring blanks. (See example, Appendix D, page 86.)

PHYSICAL DIMENSIONS OF STIMULUS BLOCK (3cm)

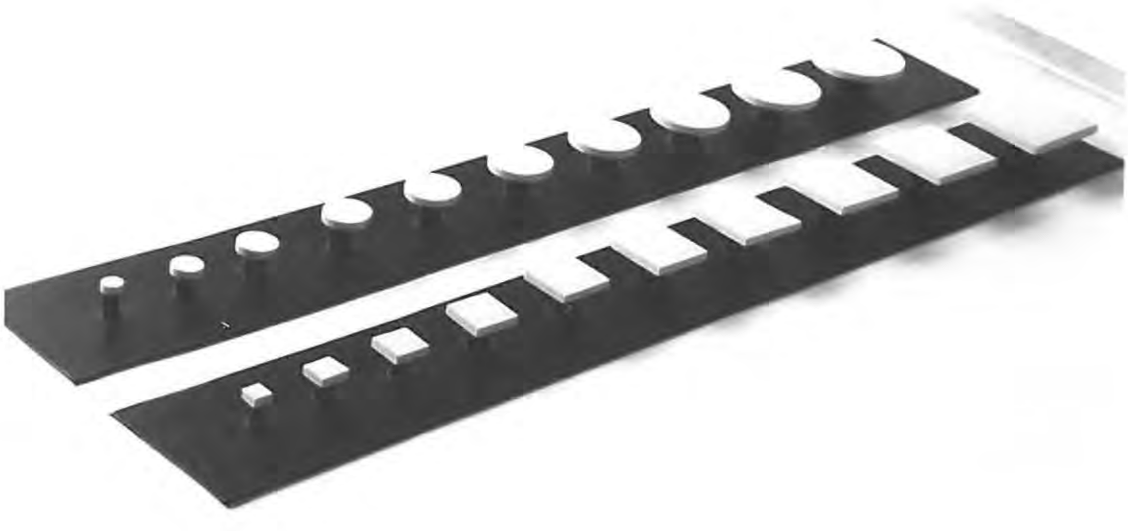




Box concealing the optical system which produced the sensory conflict situation



Cross-sectional view.



Standard arrays.

MEAN AGES OF SUBJECT GROUPS

N = 8

XHOSA			WHITE		
Age Group	Months	= Years	Age Group	Months	= Years
1	163.88	13.66	-	-	-
2	150.75	12.56	-	-	-
3	139.38	11.62	1	132.88	11.07
4	126.63	10.55	2	120.88	10.07
5	113.	9.42	3	108.75	9.06
6	100.13	8.34	4	99.38	8.28
7	95.13	7.93	5	94.24	7.85
8	83.63	6.97	6	80.13	6.68
9	69.63	5.80	7	64.63	5.39

SENSORY DOMINANCE STUDY

Group:	Age:	Date: ....
No:	Name:	

Experiment A:

TEST I Stimulus: Tactile; comparison Tactile only.

	S	R
Block 1.		

TEST III Stimulus: Visual; comparison Visual only.

	S	R
Block 1.		

TEST III Stimulus: Visual and Tactile; comparison Visual only.

	S	R
Block 2.		

TEST IV Stimulus: Visual and Tactile; comparison Tactile only.

	S	R
Block 3.		

TEST V Stimulus: Visual and Tactile; comparison Visual and Tactile.

	S	R
Block 1.		

SENSORY DOMINANCE STUDY

Notes to the Interpreter

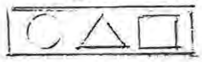
Before S. arrives please check table of practice blocks (see list below).

1. Communications check

1.1 Chn. will be shown an assortment of paired wooden blocks in a variety of shapes and colours. These will not include the actual blocks used for that particular subject. The aim is to teach the child the concept of 'matching', i.e. of "finding a partner" which is the same as the block pointed out by the E.

Pick up any block and say:

"Find a block which is exactly the same as this one - one that matches this one." If the very small children do not understand, say "Where is this one's mate/partner?"

1.2 Introduce the idea of a formboard - present empty board  and give S. the  and the shape NOT to be used in the experiment, i.e. if the S. is to work with square blocks, avoid presenting the square.

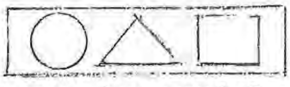
1.3 The idea of grading shapes according to size will be practised next. A formboard showing simple pictorial cutout shapes graded through 5 sizes will be shown to the child. The shapes will then be removed and then say:

"Now you must try to put these (cars/swans/oranges, etc.) back into their right places." If the child makes a mistake, say: "Must the hole be bigger or smaller?" Then remove the shapes again, and giving the S. just one shape, say: "Show me where this one belongs."

APPARATUS

A. Items used in the preliminary communication checks included:

1. A selection of randomly sized and shaped wooden blocks of colours and finishes. Some of the blocks matched those included in the standard arrays of stimulus blocks.
2. A standard formboard (green board, white wooden shapes).



3. Several different size-graded arrays of five simple pictorial

shapes fitted into recessed spaces on formboards.

4. A small table covered with a dark cloth. The blocks are randomly arranged on this table beforehand.

EXPERIMENT INVESTIGATING SENSORY DOMINANCE

TEST V/V

Before the cover of the small window in the box is removed, say: "When this little cover (lid) is lifted off, look inside." After 3 secs. the lid will be closed again, and at the same time uncover the standard blocks. Then say: (indicating the row of blocks) "Which of these blocks is the same as the block inside the box?" If the child wants to touch the comparison block, say, "Do not touch it, just point to the one you have chosen." (It is important that the child should not at this stage feel the block at all.) (If the child is still uncertain say: "Find the mate for the block in the little window.")

TEST T/T

To the very small children explain that the blindfold will be on for a very short time only. Then demonstrate how the hand must be inserted, i.e. with the palm facing up. Using an extra block without the black fabric surround, show the child how to examine the block actively at the moment of contact. Close the blindfold and say: "Put your hand into the box." After 3 secs. of active tactile examination, pull the arm out gently, (by the elbow) and propel the arm into the general direction of the comparison board. Then say: "Here is a row of blocks. Use your hand to find the block which is the same as the one in the box."

TEST VT/V

"This time you will look through the window and use your hand to feel the block in the box."

The child's hand will be restrained until the exact moment when the window is opened because viewing and feeling must commence simultaneously. After 3 secs. the child's hand is withdrawn, then say: "Point to the block which is the same as the one in the box."

TEST VT/T

The row of comp. blocks will be covered. (Blindfold in up position). Instructions will be as for VT/V, i.e.: "This time you will again look through the window and use your hand to feel the block in the box." After 3 secs. pull down the blindfold, remove the cover from the comp. blocks and proceed as for test T/T.

TEST VT/VT

This time no blindfold will be needed. Proceed as for Test VT/V, but after 3 secs. say: "You may use your hand to help you choose the matching block."

TRANSFORMATION OF RAW SCORES INTO DOMINANCE SCORES

Block 5 was usually seen as having been magnified to 9, hence

Block	magnified to	"Block"
2	"	4
3	"	5
4	"	7
5	"	9
6	"	11

Block is size expected from pure touch, while "Block" is size expected from pure vision.

Therefore the scale will be in units above the pure touch base, in terms of proportion of distance towards the pure vision base.

1. Vision (only) will be datum; i.e. number chosen in first visual exposure is datum; Index 100 i.e. the first visual judgment = 100.

2. Tactile (only), first exposure, will be 0.

3. The scale runs from Vision only (100) to Tactile only (0); so transfer 1st Visual judgment to 1st Tactile judgment to a scale of 100 to 0, e.g. taking $9 \longrightarrow 5$

   $9 = 100$
   $5 = 0$ and

   therefore the transformation applicable is

   $9 \longrightarrow 100$
   $8 \longrightarrow 75$
   $7 \longrightarrow 50$
   $6 \longrightarrow 25$
   $5 \longrightarrow 0$

L For "Large" blocks, i.e. 4, 5, and 6 - use the ff. scales:

For V/V, T/T and VT/VT:

4	5	6	7	8	9	10	11	12
-25	0	25	50	75	100	125	150	175

For VT/V:

4	5	6	7	8	9
0	33.3	66.7	100	133.3	166.7

For VT/T:

5	6	7	8	9	10	11
-20	0	20	40	60	80	100

S For "Small" blocks, i.e. 2, 3, and 4 - use the ff. scales:

For V/V, T/T and VT/VT:

2	3	4	5	6	7	8
-50	0	50	100	150	200	250

For VT/V:

2	3	4	5	6
0	50	100	150	200

For VT/T:

3	4	5	6	7	8
-33.3	0	33.3	66.7	100	133.3

FREQUENCY DISTRIBUTION OF INDIVIDUAL VISUAL DOMINANCE SCORES

CONTROL TEST : V/V

Mode (100)

Age	-50	-25	0	25	50	75	100	125	150	175	200	225	250	
13					1	1	5	0	1					
12							4	1	3					
11					4 1	1 0	2 4	1 1	1	0	1			
10			1	0	1 0	2 2	4 4	1 0	1					
9					1 1	2 1	3 6	1	1					
8	1	0	1	3 0	1 1	0 3	3 2	0	0	1				
7					1	0 3	4 3	2 0	1 1	0	1			
6			1	0	3 2	3 0	1 2	0 0	1 2	0	0	0	1	
5			2	0	1	1	1 8	0	1	0	2			
Wh. Bl.	0 1	0 0	2 3	3 0	12 6	9 10	18 33	5 2	4 9	1 0	2 2	0 0	0 1	56 72
Σf.	1	0	5	3	18	19	56	7	13	1	4	0	1	128

FREQUENCY DISTRIBUTION OF INDIVIDUAL
VISUAL DOMINANCE SCORES

CONTROL TEST : T/T

Mode

Age	-50	-25	0	25	50	75	100	
13			 3	 1	 4			
12			 3	 3	 2			
11			6 1	2 3	 4			
10	 1	 0	5 3	3 2	 0	 0	 2	
9			2 1	3 3	2 3	0 0	1 1	
8		 1	3 3	0 1	4 3	1		
7		 1	5 4	1 1	1 1	0 1	1	
6			3 4	1 0	3 1	0 0	1 3	
5		1	5 1	0 3	0 4	1	1	
Wh. Bl.	0 1	1 2	29 23	10 17	10 22	2 1	4 6	56 72
$\sum f$	1	3	52	27	32	3	10	128

FREQUENCY DISTRIBUTION OF INDIVIDUAL VISUAL DOMINANCE SCORES

EXPERIMENTAL TEST : VT/V

Mode

Age	0	20	33.3	50	66.7	100	133.3	150	166.7	200	
13	 1	 0	 1	 4	 2						
12	 2	 0	 0	 0	 2	 4					
11	1	0	2 2	2 3	2 0	0 3	0	0	0	1	
10	1	0	1 1	4 3	1 3	0 1	0	0	1		
9	1	0	3 3	3 3	1 1	 0	 0	 1			
8	 4	 0	2 1	3 3	0	3					
7			1	3 2	2 2	2 1	 2	 1			
6			1 2	2 0	1 4	3 0	1 0	 0	 2		
5	 2	 2	1 4	0	1	6					
Wh. Bl.	3 9	0 2	11 14	17 18	8 14	14 9	1 2	0 2	1 2	1 0	56 72
Σ f	12	2	25	35	22	23	3	2	3	1	128

FREQUENCY DISTRIBUTION OF INDIVIDUAL VISUAL DOMINANCE SCORES

EXPERIMENTAL TEST : VT/T

Mode

Age	-40	-33.3	-20	0	20	33.3	40	60	66.7	80	100	133.3	120	166.7	
13															
				2	2	1	1	0	3						
12															
				2	1	1	1	1	2						
11				3	1	2	1	0	1						
				1	2	3	1	1							
10			1	3	1	3									
				1	2	2	1	1	0	0	0	1			
9				1	1	4	1	1							
			1	0	3	4									
8	1	0	3	3	0	0	1								
		1	1	1	2	0	0	0	3						
7				3	2	2	0	0	0	1					
				2	1	1	1	1	2						
6			1	0	2	3	0	0	1	1					
						2	0	0	4	0	0	0	0	2	
5		1	0	2	2	1	0	1	1						
				2	2	4									
Wh.	1	1	5	15	9	15	3	2	3	2	0	0	0	0	56
Bl.	0	1	2	11	15	17	5	4	14	0	0	1	0	2	72
Σf	1	2	7	26	24	32	8	6	17	2	0	1	0	2	128

FREQUENCY DISTRIBUTION OF INDIVIDUAL
VISUAL DOMINANCE SCORES

EXPERIMENTAL TEST : VT/VT

Mode

Age	-25	0	25	50	75	100	125	150	
13		 4	 2	 0	 2				
12		 2	 0	 2	 2	 2			
11		2 2	 2	6 1	 0	 2	 1		
10		3 2	2 2	3 3	 0	 1			
9		2 1	2 3	4 3	 0	 1			
8		2 3	2 1	1 3	1 0	0 1	0	2	
7		1 1	1 1	5 3	0 1	1 2			
6		1	0 1	4 3	0 1	3 1	 0	 2	
5	1	1	0 1	0 6	0 1	5	0	1	
Wh. Bl.	1	12 15	7 13	23 24	1 7	9 10	0 1	3 2	56 72
Σf.	1	27	20	47	8	19	1	5	128

Results of Mann-Whitney U-Test used for a comparison of responses resulting from stimulus blocks that were different in shape

	Set	U	U_1	N_1	N_2	p
Test V/V						
W	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	88.00	108.00	14	14	ns
W	1.1.2. + 2.1.2. 1.2.2. + 2.2.2.	64.50	131.50	14	14	ns
Xh.	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	136.50	151.50	16	18	ns
Xh.	1.1.2. + 2.1.2. 1.2.2. + 2.2.2.	95.50	160.50	16	16	ns
Test T/T						
W	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	87.00	109.00	14	14	ns
W	1.1.2. + 2.1.2. 1.2.2. + 2.2.2.	90.00	106.00	14	14	ns
Xh.	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	143.50	144.50	16	18	ns
Xh.	1.1.1. + 2.1.1. 1.2.2. + 2.2.2.	95.50	160.50	16	16	ns
TestVT/V						
W	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	97.00	99.00	14	14	ns
W	1.1.2. + 2.2.2 1.2.2. + 2.2.2.	84.50	111.50	14	14	ns
Xh.	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	133.50	154.50	16	18	ns
Xh.	1.1.1. + 2.1.1. 1.2.2. + 2.2.2.	108.00	148.00	16	16	ns

	Set	U	U_1	N_1	N_2	p
Test VT/T						
W	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	73.00	123.00	14	14	ns
W	1.1.2. + 2.1.2. 1.2.2. + 2.2.2.	95.00	101.00	14	14	ns
Xh.	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	142.00	146.00	16	18	ns
Xh.	1.1.2. + 2.1.2. 1.2.2. + 2.2.2.	104.00	152.00	16	16	ns
Test VT/VT						
W	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	91.00	105.00	14	14	ns
W	1.1.2. + 2.1.2. 1.2.2. + 2.2.2.	95.00	101.00	14	14	ns
Xh.	1.1.1. + 2.1.1. 1.2.1. + 2.2.1.	128.00	160.00	16	18	ns
Xh.	1.1.2. + 2.1.2. 1.2.2. + 2.2.2.	114.00	142.00	16	16	ns

Results of Mann-Whitney Test of possible influence of Test order.

(Order 1, 2, 3, 4, 5 vs. 2, 1, 3, 4, 5)

	Set	U	U_1	N_1	N_2	p
Test V/V						
W	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	79.00	117.00	14	14	ns
W	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	89.00	107.00	14	14	ns
Xh.	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	100.50	188.50	17	17	ns
Xh.	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	73.50	182.50	16	16	ns
Test T/T						
W	1.1.1. 1.2.1. vs 2.1.1. 2.2.1	85.00	111.00	14	14	ns
W	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	90.00	106.00	14	14	ns
Xh.	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	99.00	190.00	17	17	ns
Xh.	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	95.50	160.50	16	16	ns
Test VT/V						
W	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	65.00	131.00	14	14	ns
W	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	89.50	106.50	14	14	ns
Xh.	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	125.50	163.50	17	17	ns
Xh.	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	124.00	132.00	16	16	ns

	Set	U	U_1	N_1	N_2	p
Test VT/T						
W	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	77.50	118.50	14	14	ns
W	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	68.50	127.50	14	14	ns
Xh.	1.1.1. 1.2.1. vs 2.1.1. 2.2.2.	132.50	156.50	17	17	ns
Xh.	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	119.50	136.50	16	16	ns
Test VT/VT						
W	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	76.00.	120.00	14	14	ns
W	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	67.00	129.00	14	14	ns
Xh.	1.1.1. 1.2.1. vs 2.1.1. 2.2.1.	138.50	150.50	17	17	ns
Xh.	1.1.2. 1.2.2. vs 2.1.2. 2.2.2.	109.00	147.00	16	16	ns

Comparison of subjects using Large (1) and Small (2) Stimulus Blocks

Test: Kruskal-Wallis one-way ANOVA

		White sample	Xhosa sample
Test V/V	1.1.1.		
	1.2.1.	W_1 : $H = 1.057$	Xh_1 : $H = 3.312$
	2.1.1.		
	2.2.1.	$p < 0.80$	$P < 0.50$
	1.1.2.		
	1.2.2.	W_2 : $H = 4.028$	Xh_2 : $H = 8.406$
	2.1.2.		
	2.2.2.	$p < 0.30$	$p < .05$ *
Test T/T	1.1.1.		
	1.2.1.	W_3 : $H = 1.504$	Xh_3 : $H = 2.874$
	2.1.1.		
	2.2.1.	$p < 0.70$	$p < .50$
	1.1.2.		
	1.2.2.	W_4 : $H = 0.321$	Xh_4 : $H = 3.600$
	2.1.2.		
	2.2.2.	$p < 0.95$	$p < .30$
Test VT/V	1.1.1.		
	1.2.1.	W_5 : $H = 5.071$	Xh_5 : $H = 1.206$
	2.1.1.		
	2.2.1.	$p < 0.20$	$p < .80$
	1.1.2.		
	1.2.2.	W_6 : $H = 1.949$	Xh_6 : $H = 0.846$
	2.1.2.		
	2.2.2.	$p < 0.70$	$p < .90$
Test VT/T	1.1.1.		
	1.2.1.	W_7 : $H = 2.703$	Xh_7 : $H = 0.133$
	2.1.1.		
	2.2.1.	$p < 0.30$	$p < .98$
	1.1.2.		
	1.2.2.	W_8 : $H = 2.584$	Xh_8 : $H = 2.098$
	2.1.2.		
	2.2.2.	$p < 0.50$	$p < .70$
Test VT/VT	1.1.1.		
	1.2.1.	W_9 : $H = 4.283$	Xh_9 : $H = 0.547$
	2.1.1.		
	2.2.1.	$p < 0.30$	$p < .90$
	1.1.2.		
	1.2.2.	W_{10} : $H = 2.480$	Xh_{10} : $H = 0.938$
	2.1.2.		
	2.2.2.	$p < 0.50$	$p < .90$

Note: This was done in two parts, e.g. W1 and W2, because the raw scores (before transformation) were not directly comparable since two sets of notation were used.

Results of Mann-Whitney U-test used for the Cross-Cultural Comparison of the Xhosa and White Groups

(Raw Scores used)

	Sets	U	U_1	N_1	N_2	p	
Test V/V	1.1.1.	12.00	51.00	7	9	-	a = .05
	2.1.1.	28.50	34.50	7	9	-	
	1.2.1.	26.50	29.50	7	8	.455	ns
	2.2.1.	23.00	33.00	7	8	.306	ns
	1.1.2.	10.00	46.00	7	8	.020	.02
	2.1.2.	17.00	39.00	7	8	.116	ns
	1.2.2.	23.00	33.00	7	8	.306	ns
	2.2.2.	21.50	34.50	7	8	.250	ns
Test T/T	1.1.1.	27.00	36.00	7	9	-	ns
	2.1.1.	28.50	34.50	7	9	-	ns
	1.2.1.	24.50	31.50	7	8	.368	ns
	2.2.1.	24.00	32.00	7	8	.347	ns
	1.1.2.	21.00	35.00	7	8	.252	ns
	2.1.2.	17.00	39.00	7	8	.116	ns
	1.2.2.	24.50	31.50	7	8	.368	ns
	2.2.2.	27.00	29.00	7	8	.478	ns
Test VT/V	1.1.1.	15.00	48.00	7	9	-	ns
	2.1.1.	19.00	44.00	7	9	-	ns
	1.2.1.	24.00	32.00	7	8	.347	ns
	2.2.1.	24.00	32.00	7	8	.347	ns
	1.1.2.	22.00	34.00	7	8	.268	ns
	2.1.2.	26.50	29.50	7	8	.455	ns
	1.2.2.	19.00	37.00	7	8	.168	ns
	2.2.2.	24.00	32.00	7	8	.347	ns
Test VT/T	1.1.1.	25.50	37.50	7	9	-	ns
	2.1.1.	27.00	36.00	7	9	-	ns
	1.2.1.	26.00	30.00	7	8	.433	ns
	2.2.1.	16.50	39.50	7	8	.105	ns
	1.1.2.	18.50	37.50	7	8	.265	ns
	2.1.2.	14.50	41.50	7	8	.068	ns
	1.2.2.	27.00	29.00	7	8	.478	ns
	2.2.2.	17.00	39.00	7	8	.116	ns
Test VT/VT	1.1.1.	24.00	39.00	7	9	-	ns
	2.1.1.	19.50	43.50	7	9	-	ns
	1.2.1.	20.50	35.50	7	8	.215	ns
	2.2.2.	26.50	29.50	7	8	.455	ns
	1.1.2.	22.00	34.00	7	8	.268	ns
	2.1.2.	22.50	33.50	7	8	.287	ns
	1.2.2.	24.50	31.50	7	8	.368	ns
	2.2.2.	17.50	38.50	7	8	.128	ns

ANALYSIS OF NUMBER OF DOMINANCE INDEX SCALE POINTS
OCCUPIED BY THE SCORES OF EACH AGE GROUP[1]

Age: / Tests:	5	6	7	8	9	10	11	12	13
V/V	9	11	7	10	5	7	7	3	5
T/T	6	5	6	5	5	7	3	3	3
VT/V	6	7	6	6	8	9	10	6	5
VT/T	8	12	7	9	6	10	6	6	6
VT/VT	8	7	5	7	5	5	6	5	4
$\sum f$	37	42	31	37	29	38	32	23	23
$\bar{X}$	7.4	8.4	6.2	7.4	5.8	7.6	6.4	4.6	4.6

[1]Xhosa and White subjects' scores were taken together.

From: A DEVELOPMENTAL STUDY OF AFFERENT-REAFFERENT INTEGRATION

By KEVIN CONNOLLY and BILL JONES

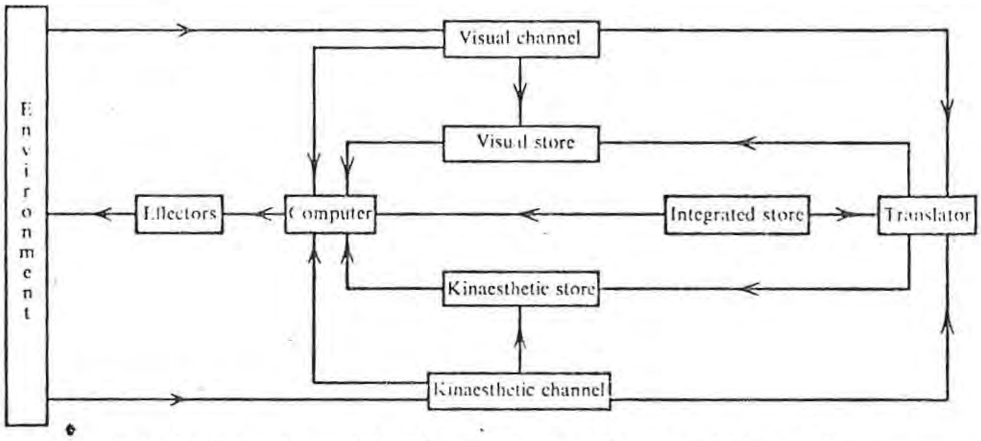


Fig. 1. Diagrammatic model for intra-modality and cross-modality matching; for details see text. Inputs to the integrated store are shown in Fig. 2.

Br. J. Psychol. (1970), 61, 2, pp. 264 & 265

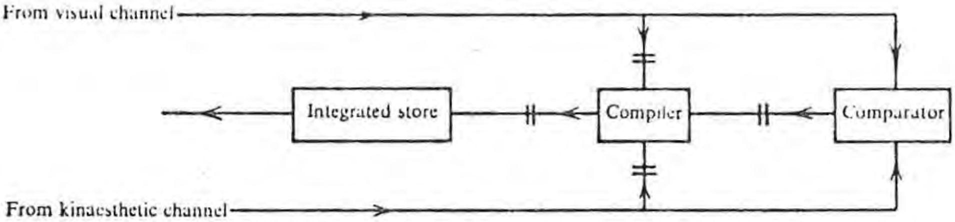


Fig. 2. Compiler unit embodying error-correcting system; for details see text. The double bars refer to the switch mechanism.

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