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Haptic Pictures, Blindness, and Tactile Beliefs: Preliminary Analysis of a Case-Study

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Abstract

Research on the identification of raised-outline drawings (*haptic pictures*) indicates that blind and sighted individuals process pictorial information similarly. To explain this similarity, the *partial overlap* hypothesis argues that pictorial representation is constrained by principles grounded on objective shape perception that are shared by vision and haptics. In contrast, the *tactile beliefs* hypothesis maintains that such similarity is not given by our tactile experience, but by indirect, meaning-based representation of such experience. In this case-study, a 13-year old child born completely blind was invited to explore and identify a set of haptic pictures. He then was invited to explain, verbally and/or by drawing, why he believed that the referents he suggested identified accurately the depicted objects. Identification and recognition memory of haptic pictures were interrelated, but unrelated to tactile beliefs. The findings support the partial overlap hypothesis.

Research on the production and identification of raised-outline drawings (haptic pictures) suggests that there is a fundamental similarity in the way blind and sighted individuals process and use pictorial information from touch. In identifying haptic pictures, blind individuals can achieve success rates which are comparable to those of blindfolded sighted individuals (Kennedy, 1993), and haptic pictures most frequently identified by blind children and adults are also those most frequently identified by blindfolded sighted children and adults (D'Angiulli, Kennedy & Heller, 1998). In addition, there are basic similarities in the way blind and sighted participants explore and extract information from raised-line displays (D'Angiulli & Kennedy, 2001) or from three-dimensional objects (Morrongiello et al, 1994). Perhaps, the best evidence of similarity is provided by the numerous case reports documenting blind children and adults making realistic pictures of common objects in form of raised-line outlines, which in most cases are readily interpretable and meaningful to sighted observers and are indeed comparable to visual drawings made by sighted peers (e.g., D'Angiulli & Maggi, 2004; 2003; Kennedy, 2003; 1993); these findings can be taken as evidence that blind individuals have a genuine understanding and appreciation of the principles of pictorial representation, similar to the sighted (Lopes, 1997).

One interpretation of this body of evidence is that the similarity in haptic picture processing between the blind and the sighted participants is a reflection of a *partial overlap* (D'Angiulli, 2004) between vision and haptics. That is, vision and haptics share some important principles of representation of form, such as ground-foreground segregation, use of lines as edges, basic geometric shapes for sides of familiar objects, and some rudiments of perspective. This may be so because the principles that inform realistic depiction in form of outline are based on objective shapes, which can be perceived haptically as well as visually. For instance, we can run our fingers around the contours of an object, and keep track of the path traced in space, thereby extracting an outline describing the form of the object represented (Magee & Kennedy, 1980). Alternatively, if the object is small enough, we can feel its contour simply by creating an imprint on our skin by pressing it onto sensitive parts of our body that offer enough points of contact with the object (Gibson, 1962).

Direct evidence of the overlap between vision and touch in picture processing comes from an experiment (Kennedy & Bai, 2002, Experiment 5) in which participants were asked to identify pictures either haptically, while blindfolded, or visually, and subsequently they were asked to judge how well the referents they mentioned fitted the themes depicted by the picture stimuli (fit judgments). The fit judgments by the group who made the judgments visually predicted picture identification accuracy from the group of blindfolded participants who made the judgments haptically. This suggests that the assessment of fit between one's identification and the depicted referent occurs similarly in vision and touch because outline picture processing is based on similar object shape criteria.

However, according to an alternative interpretation, haptic picture processing similarities in the blind and sighted participants are not related to knowledge or understanding acquired through *direct* experience of the shape of the objects. Rather, they are by-products of *tactile beliefs* (Hopkins, 2000), that is, of inferences based on aspects related to touching objects without visual feedback. The assumption is that there is no information about outline shape present at the same stage in visual and tactile processing. Thus, while visual experience itself "presents" us with outline shape, tactile experience may not do so, it may only enable us to construct some form of knowledge that describes outline shape. For example, if we run our fingers over an object like a shoe, we may represent a certain shape of it, but we would not be able to represent the two-dimensional shape of the "intersections" (i.e., L, T and Y junctions) within this object. If the shoe were cut in half along its length, the understanding of which object the corresponding contour may represent is not directly given by our tactile experience, but by beliefs derived on our tactile experience. In short, haptics would enable us to "deduce" the outline shapes of objects like the shoe by going beyond the contents of our tactile experience itself. Notice that the present use of the term 'beliefs' does not call into question the broader notion of 'theory of mind', it simply refers to 'inferred (perceptual) tactile attributes of the outline shape of depicted objects'.

The hypotheses of partial overlap and tactile beliefs have been discussed in relation to one type of experimental task, in which the blind (or blindfolded) participant explores haptically a raised-outline picture and then attempts to identify its referent object once. Another way to contrast partial overlap and tactile beliefs is by considering a task in which the participant is given the opportunity to explore and identify a picture a second time. In this case, he/she may remember having touched that configuration of lines before, even though he/she may have not known how to call it (Heller, 2002). A participant could demonstrate this type of knowledge by giving the same verbal label to a given picture twice, in both test and re-test trials. In this way, repeated naming upon second identification attempt can be related to *recognition memory* of a picture previously explored, whether correctly identified or not.

The two hypotheses here considered imply two different types of retrieval processes associated with recognition memory, as proposed in dual-process theories of recognition (e.g., Mandler, 1980). The partial overlap hypothesis would lead to argue that response repetition reflects *verbatim* memory traces of the touched patterns. On this view, re-labelling a stimulus with the same name would correspond to an identity judgment based on the surface match of the items presented on the first and second presentation. In other words, the touched patterns could even be nonsense figures, the label or meaning that the participant assigns to the picture is not mediating recognition. The job is done by item-specific, perceptual memory of the configuration of touched lines.

In contrast, the contending account leads to argue that repeating a label for a haptic picture presented as stimulus would reflect *gist* memory traces of tactile belief or meaning associated with the stimulus. Namely, the participant just retrieves the name he/she had assigned to the picture out of believing that certain raised lines correspond to salient features of the object/entity represented. In the latter case, the assumption would be that recognition involves a semantic relatedness (or similarity) judgment based on meaning match of the touched patterns.

The case study reported here may shed some new light on this recent debate concerning the nature of haptic picture processing in blind individuals. In this study, a child born completely blind was invited to explore and identify a set of haptic pictures twice in two separate blocks of trials (without receiving feedback about his identification accuracy). He then was invited to explain, either verbally and/or by drawing, why he believed that the referents he suggested may identify accurately the depicted objects. The expectation was that if haptic picture identification were indeed based on object shape perception and processing of surface form of the stimuli, then as in previous research there should be a relationship between picture identification accuracy and recognition memory (defined as repetition of the same suggestion for a given picture during re-test, regardless of the correctness of the identification), but no necessary relation between these processes and the child's tactile beliefs about what the pictures might be representing. If however haptic picture identification were primarily based on inferring the meaning of the picture, then the pictorial beliefs of this child should be associated with his accuracy in identifying the haptic pictures and in having recognition memory of them.

The work by Kennedy and Bai (2002) suggests yet a third way in which the hypotheses of partial overlap and tactile beliefs may be compared. These authors organized their pictures-stimuli into two categories. One category included pictures like a fork or a hammer. These pictures may be called *imprints* in that they represented "flattish" objects with little depth and few overlapping parts, so that they could produce a recognizable imprint on a flat surface. The other category included pictures like a table or a cup. These other pictures were "more three-dimensional figures" (Kennedy & Bai, 2002, p. 1024) and may be called *projections* as they represented three-dimensional objects by depicting overlapping object parts on a two-dimensional surface. If understanding of pictorial aspects of perspective projection (e.g., overlap of occluding edges, parallel projection, etc.) derives from tactile beliefs, for a congenitally blind child projections should be considerably more difficult to identify than imprints. For example, one would not need to grasp the principles of parallel or polar projection geometry, if one was touching the outline of a fork, as depicted from the side view along its longest dimension. However, one would need to have learned projective geometry to identify the outline describing an object with many internal overlapping parts, for example, a cabinet or a table. Indeed, haptic pictures relatively more 'committed' to perspective, like the cabinet or table, should show a relatively stronger association with the tactile beliefs (see Hopkins, 2000; p. 154-160). Conversely, if a congenitally blind child can readily appreciate overlap and parallel projection of shapes, then there should be no difference between imprints and projections in relation to their identification, recognition or association with the child's tactile beliefs. Thus, a further goal of this study was to test whether pictures that exploit aspects of perspective projections show a stronger relationship with tactile beliefs than pictures that do not depend as much on vantage point.

Method

Participant. C was a 13-year old boy completely blind from birth who attended a school for the blind in Northern Italy. Although the cause of his blindness was presumably a rare genetic disease, this was never fully confirmed. At any rate, the standard paediatric evaluation reported no pupillary reflex or light reaction at birth. C started writing and reading Braille by age of 7. He was originally recruited in the context of a case-study series investigating the first drawings by blind children. Because by that time he had already made various drawings, he was not included in that study. He was however contacted again and invited to participate in the present study. Both child's assent and parental consent were conditions for his participation. Although C had been drawing since he entered school, this activity was sporadic both at school and at home. As a result, it is not possible to provide a precise estimate of the number of drawings he usually made, say, in the period of a week. While attending school, C received instruction on how to draw geometric shapes using a variety of commercially available materials and kits designed as educational aids for children with visual impairment. He also received some tuition for making 'artistic' raised-line pictures (i.e., not necessarily realistic pictures or even portraits of actual objects).

Materials. The stimuli were twelve raised-line drawings, partly taken from D'Angiulli et al (1998) and partly adapted from Kennedy and Bai (2002). Eight pictures were used as *targets* on the first and second blocks of identification trials (henceforth referred to as 'block 1' and 'block 2' respectively). These pictures represented: apple, cup, scissors, telephone, key, happy face, bottle, and table. Three other pictures, representing fork, leaf and hand silhouette, were included with the targets on block 2 as *distracters*. A raised-line drawing of a tree was used for practice.

The stimuli were produced with a raised-line drawing kit (available from SIH, The National Sweden Agency for Special Education, Solna, Sweden) which consists of a board (21 cm x 31 cm) that has one side coated with rubber; when plastic sheets are fixed on the board, pressure with a ball-point pen produces raised lines. Each picture was drawn on a separate plastic sheet with lines approximately 0.5 mm high. Regardless of shape, all figures were inscribed within a 16.5 cm x 14.5 cm rectangle (marked in pencil).The set of pictures presented on block 1 were drawn on Mylar plastic sheets manufactured in Sweden, whereas the set of pictures presented on block 2 (copies for the targets and originals for the distracters) were drawn on Poly film sheets available from Sewell Metal Processing Corporation (Woodside, New York); the different textures of these two types of plastic sheets can be readily picked up by touch.

In keeping with the classification of picture-stimuli described in the Introduction, half of the targets (i.e., apple, key, scissors, and face) were "imprints". The other half (i.e., cup, telephone, bottle, and table) were "projections".

Procedure. The experiment consisted of two blocks of identification trials. The procedure followed in all identification trials was an adaptation of the one used by Kennedy and Bai (2002; Experiment 1). The participant was given practice on the raised-line picture of a tree, and then he was asked to identify the other pictures, one at the time. C was allowed to reflect on his responses by thinking aloud. However, he was invited to provide one final identification response only, and to give one final response even if unsure. Correct identification required offering the object names listed above (apple, key, etc.) or synonyms (e.g., phone for telephone). No feedback about accuracy of identification was provided in any trial, except practice.

In block 1, the presentation order was random. In block 2, the presentation order differed from that on block 1 and was 'semirandom', that is, while the order of all targets was randomised, leaf, fork and hand silhouette were presented as the first, fourth and eight pictures respectively. The randomization was used to show that block 2 was not just a repeat of block 1, and to discourage C to merely repeat the sequence of names he had said in block 1. Also, to increase bias towards novelty, in block 2 the targets were copies drawn on a slightly different medium. Hence, in the second identification trials, C could not base his response on features other than the raised-outline shapes.

After block 1, there was a break of 30 minutes, immediately followed by block 2. In each trial of block 2, once that C provided the name of an object as his final identification response, the experimenter elicited tactile beliefs about a picture by asking "Why do you think this is a drawing of a ____ [repeat of the name provided by the child]?" If the child's identification response was correct the experimenter simply moved on to the next stimulus. Alternatively, if the identification response was incorrect, the experimenter first asked the question: "May this be the drawing of a ____ [correct object name]? Could you explain why you believe that this may/may not (depending on the response of the participant) be the drawing of a ____ [correct object name]?" If C did not respond after 1 minute, or declared/showed not to be able to explain himself, for example, hesitating to respond, the experimenter handed him a drawing kit with a blank Mylar sheet and a pen, then asked: "Would you like to show me how a ____ [correct object name] should be drawn?" In the latter instances, the rationale for asking the child to provide a drawing as "graphic commentary" of his beliefs was twofold. First, drawing activity can be an aid for both verbalization and thinking in sighted and blind children (Millar, 1994). Second, on the basis of previous research (e.g., Kennedy, 2003; D'Angiulli & Maggi, 2004) it was reasonable to expect, at least in some trials, very little or no usable verbalization. Thus, in the event that a response was unclear, incomplete or ambiguous, the drawing could reveal critical information about the child's beliefs.

The experiment was carried out in a quiet room in the child's school; it lasted approximately one hour and forty-five minutes (including the break). The experimenter was a trained, experienced support teacher unfamiliar with the hypotheses of the study.

Coding and analysis. In identifications trials, correct response was denoted with 1, incorrect response was denoted with 0. Recognition was defined as repetition in trial 2 of the identification response given in trial 1, regardless of correct identification (as in D'Angiulli & Waraich, 2002). Recognition (response in trial 1 being repeated in trial 2) was indicated with 1, whereas missed recognition (response being changed in trial 2) was indicated with 0.

Tactile beliefs were operationally defined in terms of object names that C "accepted" or "rejected" in relation to the trials of block 2. For each picture, C's acceptance or rejection was based on response to the first belief-eliciting question following accurate identification on trial 2, or based on response to the second belief-eliciting question in case of inaccurate identification on trial 2. These responses were coded as follows: C's Acceptance that an object name was the correct referent for a given drawing was coded with 1, rejection of the object name was coded with 0.

Agreement among pairs of dependent measures (i.e., first identification, second identification, recognition and belief) was defined by the occurrence of the same coding number relatively to a particular picture stimulus (1 and 1, or 0 and 0). Small-sample probability estimates for the agreement were based on computation of all agreement permutations, i.e., p = 1/N! (Siegel & Castellan, 1988).

Results

In block 1 (trial 1 for a given picture) and in block 2 (trial 2 for a given picture), C identified over 60% of target pictures – 75% and 62%, respectively (see Table 1).

In block 1, most of C's verbalizations contained descriptions of salient parts of the pictures which might have suggested the name of possible object referents fitting the configuration of raised-lines (e.g., buttons for a telephone) C provided confidently one final response for all targets except while exploring apple. Before identifying it as an apple, C interpreted that picture as representing a face.

The agreement between recognition and identification responses in both blocks was above chance (p = .001 for first identification, and p = .0002 for second identification). Thus, response repetition was associated with identification.

Only a minor proportion of pictures (37%) were accepted by C as appropriate representations of the named objects. There were no associations between C's acceptance/rejection of the names, identification, and recognition.

Three of the stimuli that C drew were rejected as inadequate. Two of these drawings depicted a key. Both drawings were considerably smaller than the picture he attempted to identify. There were two aspects he could not "understand". The first was the groove of the key, which "felt too widely-spaced". The second was the big hole in the circular handle of the key. His remarks suggested a discrepancy between the specific kind of key C had in mind and the one depicted by the stimulus. The stimulus represented a basic standard key for wood doors, whereas C had in mind the key of his home which had an armoured entrance door. (Since the experimenter happened to have a key for an armoured door, during debriefing he let C hold and explore that key, then asked and received positive confirmation that was indeed the kind of key C intended to represent in his two drawings of the key).

Table 1. Identification, recognition, and accepted object names for haptic pictures provided by a 13-years old child born completely blind.

Picture	Type	Identified		Recognized	Accepted (Drawn)
		Trial 1	Trial 2		
Apple	I	1	0	0	1
Cup	P	0	0	1	0 (D)
Scissors	I	1	1	1	0
Telephone	P	1	1	1	1
Keys	I	0	0	1	0 (D)
Face	I	1	1	1	1
Bottle	P	1	1	1	0
Table	P	1	1	1	0 (D)
Proportion		6/8	5/8	7/8	3/8

Note. I = imprint, P = projection.

With regards to the drawing of a cup, C stated that the graphic detail representing the cup handle was sufficiently appropriate. However, he observed that in the picture of the cup a very salient feature was missing: the "internal cavity which usually contains liquids". To explain, C also made a drawing. He then made a similar remark regarding the opening of the bottle in the picture representing this object, and said that was the reason why he did not find either stimulus to be a "good" haptic picture.

C identified and recognized the pictures depicting a table and a pair of scissors but rejected both as inappropriate. To show how a table should be depicted, C made a drawing. In contrast with the stimulus, C's drawing had no parallel projection, it showed simply a rectangle as the tabletop and, attached to it, extending legs of approximately same length, with no hint of occluded parts of any of the legs. Regarding scissors, C commented that the orientation made the picture difficult to interpret.

Finally, when each dependent measure, verbalization and drawing was examined with the intent to uncover differences between imprints and projections, there was no evidence of any reliable difference between these subsets.

Discussion

For most haptic pictures, there was strong agreement between C's response to the identification in the first and in the second trials. Because the latter agreement was based on perceptual evaluation of shape, the agreement between identification responses and recognition memory, as reflected by response repetition in the second trials, was in all probability also based on item-specific, verbatim trace of the touched configuration of raised-lines. This finding is consistent with previous research on blind individuals

(D'Angiulli, Kennedy & Heller, 1998; D'Angiulli & Waraich, 2001) and on sighted individuals matched to samples of blind participants (Kennedy & Bai, 2002). Indeed, the effect sizes obtained in those studies were very similar to the effect sizes obtained in the present case-study. Thus, it would seem that the relationships highlighted in this study are consistently found for the same subset of raised-line pictures that were also used in other studies.

However, the results pointed out an apparent dissociation between identification and pictorial belief, since C identified correctly some stimuli he did not deemed to be adequate or "good" haptic representations. (Notice that the issue here is not whether *more* or *less* drawings were recognized than accepted as good drawings, the hypotheses only concerned a *difference* or dissociation between the two measures). Because recognition memory was unrelated to tactile beliefs as well, it is reasonable to conclude that C's evaluation of the haptic pictures in the identification trials was not based on attempts to encode the raised-line configurations semantically. Therefore, these findings are clear evidence in favor of the partial overlap hypothesis.

D'Angiulli (2004) proposed that a well-defined, testable conceptualization of partial overlap could be derived from the *convergent active processing in interrelated networks* model (CAPIN; cf., Millar, 1994), a theoretical framework that aims at explaining both the production and the identification of haptic pictures in blind and sighted children. According to one interpretation of Millar's theory, a key implication of CAPIN would be that blind children's representation of raised line drawings relies on touch and movement, but, most important, it relies on the partial overlap or convergence between actual sensory inputs and *absent* visual information. Consequently, only *some* aspects should be equivalently represented in haptics and vision.

Assuming that the judgment of sighted observers is the golden standard, CAPIN can be operationally translated as follows: If the symbols contained in blind children's drawings reflect partial overlap and convergent representations, only a portion of those symbols will be identified by sighted observers, and respectively only a portion of drawings will be identified. D'Angiulli (2004) tested this prediction by re-examining the data from a longitudinal study of spontaneous raised-line drawings made by congenitally, totally blind children (aged 12) who had never drawn before. Naïve sighted judges viewed and attempted to identify the objects represented in the blind children's drawings, they also rated the contents of the pictures along various scales of recognizability, complexity, composition styles, salient features, depiction direction, and depiction of vantage point, which had been adapted from categories identified in previous research on drawing development in blind as well as sighted children. The identification of single parts of the drawings was strongly related to the identification of the entire drawing, but the agreement between the sighted coders along the various scales was good, not perfect. Because interrater agreement provided an operational crude measure of the intermodality associated with the content of the blind children's drawings, it was concluded that blind children depicted *some* aspects common to vision and touch: aspects of motion of objects, surfaces, edges, three-dimensional solid structure of objects, and so on. Thus, in line with the interpretation of CAPIN, the data demonstrated partial overlap, not complete.

Whether partial overlap is the correct explanation or not, one legitimate objection to the notion of a dissociation between identification and pictorial belief is that C might not have explored the unidentified stimuli efficiently or systematically enough to note or/and integrate some parts of the pictures, and therefore his beliefs might just have been biased by this variable. Because copying reflects how systematically haptic pictures are explored (D'Angiulli & Kennedy, 2001), during debriefing C was asked to copy the two unidentified, rejected pictures, of a key and a cup, for which he also provided his own free drawings. Both of these copies were very similar to the copied stimuli. This showed that although he could not provide a correct identification and believed he was touching another object, C considered all parts of the two configurations of raised-lines. Further support for the dissociation between identification and belief comes from the converse case, illustrated above, in which C suggested an alternative way to draw a table even though he could identify the stimulus presented.

It is in order to comment on one question that arises from the finding that there was a weak relationship between drawings that were recognized and those accepted as good representations. Would blindfolded sighted children tested in the same conditions behave any differently? On the partial overlap (or CAPIN) account, there is no reason why they would. However, this question is being answered empirically in a forthcoming investigation.

Consistent with other studies (Kennedy, 1993), there were no reliable differences between C's responses to the haptic pictures that represented parallel projection and C's responses to the haptic pictures that did not involve that type of representation. Although the set of pictures tested was relatively small, this result suggests that C could readily appreciate overlap and parallel projection of shapes. Hence, one of the overlaps between vision and touch may be the ability to identify and recognize pictures with some types of projection (Kennedy & Bai, 2002).

The latter conclusion, however, is undermined by the fact that the data on C's ability to identify "imprint" stimuli, and failure to identify "projection" stimuli, is not particularly clear-cut. The child examined four different objects that were twice presented either as imprints or projections, and he correctly identified 6/8 projections and 5/8 imprints. Given the few number of trials and given that the type of picture (imprint vs. projection) is confounded with object type, interpreting this result is difficult, with the consequence that further research is needed to clarify these preliminary observations.

The present findings have important implications for theories of pictorial processing as they relate to aesthetics. As argued by Lopes (1997), it is certainly possible that haptic pictures can produce genuine aesthetic enjoyment to blind individuals. Nevertheless, this may not necessarily have anything to do with how he perceived and evaluated the haptic pictures. C formed the belief of appropriate meaningful pictures when he could not identify them correctly. All together, he rejected as inappropriate pictures that he could identify perfectly well. The pattern of dissociation suggests an alternative account in which some stages of haptic processing may be as "modular" and as "belief-impenetrable" (Pylyshyn, 1989) as some stage of visual processing. Independently of such modularity and impenetrability, it may be argued that the enjoyment of haptic pictures or, simply, of haptic lines can be reached through beliefs, as assumed by Hopkins. This does imply (contra Lopes) that the essence of the experience of realistic pictures achieved indirectly through haptics differs from the experience achieved directly through vision.

Nonetheless, the present case-study shows (contra Hopkins) that whether or not they have an aesthetic correlate, and regardless of the type of beliefs they may be associated with, the basic perceptual principles that govern realistic depiction are indeed shared by vision and touch. Thus, even considering all limitations of this study, evidence from single-cases and small-samples studies involving blind participants are accumulating and seem to converge on one conclusion: The partial overlap among touch and vision still seems the most straightforward and parsimonious explanation of why congenitally completely blind and sighted individuals can process pictorial information similarly, even though they adopt strikingly different modes to access information from the world.

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