PHANTOM EXPERIENCES FOLLOWING AMPUTATION IN CHILDHOOD

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When a person has lost an arm or leg in an accident, or as the result of surgery, he typically continues to feel the lost extremity as if it were still present. On first awaking from the anaesthesia such a patient may not believe that the leg has actually been removed until he can convince himself by looking under the covers. Even once he knows beyond doubt that it is gone, the foot of the amputated leg may itch and, as he reaches down to scratch it, he reaches for an empty space. He may feel the bed sheets on the arm or leg, he may feel a mild, perhaps pleasant tingling, a phenomenon which Henderson and Smyth regard as basic (Henderson and Smyth, 1948), or, more rarely, he may have pain. He may feel that he can wiggle his fingers or toes, flex or extend the wrist or ankle, and that he can perform these movements more or less at will. Despite his knowledge of the amputation which has been performed the patient may 'forget' and reach out with his missing hand to grasp something, or to steady himself, or he may step on the phantom foot and fall.

The earliest published account of phantom experiences following amputation is probably that of Ambroise Paré, the great French military surgeon of the sixteenth century (Keynes, 1952). A hundred years later Descartes, who evidently did not know Paré's treatise, described the sensations of a girl whose arm had been amputated at the elbow and complained about pain in the phantom fingers (Riese, 1958). Melville's scene between Captain Ahab and the ship's carpenter indicates that early in the nineteenth century, and probably long before that, there was a certain amount of popular knowledge concerning amputation phantoms (Melville, 1959). The carpenter, puzzled though he is by Captain Ahab's story, has heard 'that a dismasted man never entirely loses the feeling of his old spar, but it will be still pricking him at times'.

The first systematic and fairly detailed description was given by Guéniot just a hundred years ago (Guéniot, 1861). Soon afterwards appeared Weir

Mitchell's classical article, based on the observations of several hundred Civil War veterans then residing at the 'Stump Hospital' in Philadelphia (Mitchell, 1871). Mitchell coined the several terms 'phantom limb', 'ghost limb', and 'sensory ghost', which are still in use today.

The intriguing nature of the phantom is attested by the large number of publications on this topic which have appeared during the last ninety years.² The central argument of much of that literature concerns the 'peripheral' versus the 'central' origin of the phantom, a controversy which, at least in its more naïve form, is essentially out-dated. Not out-dated, however, is Henry Head's notion of a cognitive schema of the body, a concept which he applied only incidentally to the amputation phantom (Head and Holmes, 1912). To be sure, already Captain Ahab saw lurking behind the phantom an invisible double of the whole person, and Guéniot (1861) had come close to anticipating Head's schema. But it was Head who explicitly formulated the concept and spelled out the two main characteristics of the body schema: its genesis as a function of past sensory experience, and its active determination of precepts initiated by newly arriving sensory inputs. This notion has gained fairly wide acceptance among students of phantom phenomena (*e.g.* Pick, 1915; Schilder, 1950; Hécaen and Ajuriaguerra, 1952; Russell, 1959), despite the fact that some of its implications remain to be clarified (Oldfield and Zangwill, 1942a and b, 1943). Foremost among these is the concept of past experience.

If the amputation phantom is to be regarded as a sign of a body schema which persists despite the physical alteration wrought by amputation, and if one assumes that such a schema is built up from past sensory experience, then the problem of phantom experience following amputation in childhood is a crucial one. In an earlier publication I have shown that phantoms are absent for extremities missing from birth, and have argued that this is so because the absent limb has never been experienced, and thus has never been a part of the body schema (Simmel,

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²A detailed review of the literature is in preparation.

TABLE I
COMPOSITION OF FOUR GROUPS OF SUBJECTS

Group of Subjects	Total		Sex			Age (yr.) at Amputation		Age (yr.) at Interview		Prosthesis			Side of Amputation		
	Subjects	No. of Amputations	M	F	?	Range	Median	Range	Median	Yes	No	?	R.	L.	Bi-lateral
a	27	31	14	4	9	0-2 to 9	5-0	3-6 to 45	18	12	1	18	11	4	4
b	41	45	29	12		0-3 to 9-11	6-0	4-3 to 60	6-0	35	6	4	22	15	4
c	39	41	31	8		10-6 to 18	15-6	11-7 to 72	17	32	4	5	20	17	2
d	29	33	12	17		2 hr. to 17 yr.	8-1	4-2 to 34	12-0	25	5	3	18	7	4

1961). I am now addressing myself to the question of how much and what kind of experience does seem to be necessary for an extremity to become part of the body schema, and for a phantom to result upon amputation. Leaving aside the details of phantom experience *per se*, I shall simply try to indicate the presence or absence of phantoms as a function of earlier sensory experience.

SUBJECTS AND PROCEDURE

Data are available from four groups of subjects who had suffered the loss of one or more extremities in childhood or youth. Table I presents a summary of the vital statistics and other relevant information for each of these groups. Further details concerning individual subjects are given in Tables II, III, and VI.

GROUP A In this group are included 27 subjects having undergone a total of 31 amputations of previously normal extremities before the age of 10 years. None of these was examined personally by the writer. For 26 of the subjects the material was culled from the existing literature; a report concerning the remaining subject was received from a physician who had examined this patient some years ago. In general the information given for this group of subjects is relatively sketchy and often incomplete.

GROUP B This group contains 41 subjects who had undergone a total of 45 amputations of previously normal extremities before the age of 10 years.

GROUP C This group is composed of 39 subjects having undergone a total of 41 amputations of previously normal extremities during their second decade of life. It may be of interest to note that one half of the amputations in this group resulted from accidents involving gun play or explosions of fireworks or home-made bombs.

GROUP D There are 29 subjects in this group, with a total of 33 amputations of congenitally malformed extremities which had been surgically removed before the age of 20 years, largely in order to fit a useful prosthesis.

All subjects in groups b, c, and d were examined personally by me. With few exceptions they were seen between 1956 and 1958 in the Amputee Clinic of the Research and

Educational Hospitals at the University of Illinois.³ The patients attended this clinic primarily for the prescription and adjustment of artificial limbs. Within the limits of a sometimes complicated schedule they represent successive clinic cases.

The older patients were interviewed individually. Information about the younger patients was obtained both from the children themselves and from relatives who accompanied them to the clinic and were present during the interview. Most patients were seen only once, though a few were questioned on repeated occasions.

Two considerations guided the courses of the interview. First, in view of the subjective nature of the phantom it was important for the examiner not to suggest to the subject phenomena which the latter had never experienced. Secondly, a subject with a phantom is aware of the discrepancy between his perceptual experience and the fact of the loss of the limb, and he may be hesitant to talk about an experience contradicted by physical reality, lest he be regarded as untrustworthy or even *non compos mentis*. Actually, neither of these turned out to be a major problem. The phantom which follows amputation is a vivid experience and, given the opportunity, most patients mention it spontaneously. By contrast, even intelligent patients who have never had this experience seem to have some difficulty in understanding what the examiner is trying to talk about, even though they may have heard about phantoms from acquaintances who had lost a limb, or from other patients in the waiting room. It appears, therefore, that the role of suggestion cannot have been a very significant one. Similarly, while a few subjects were initially hesitant to admit to phantom experiences, they seemed to be considerably relieved when they discovered that the examiner knew about phantoms and did not consider them as anything unusual.

A typical interview proceeded as follows: At the outset the subject was asked to recount the circumstances leading to and surrounding the amputation. Most subjects had either lost consciousness at the time of the accident or had undergone surgery under general anaesthesia. At this juncture the examiner asked: 'What happened when you woke up?' More often than not the reply was: 'I didn't think the leg was gone, I could still feel my toes,'—'I looked and it was gone but I still felt it, I feel it now,'—'I could feel my toes, I could wiggle them the same as you can wiggle yours,'—'I could still feel my hand and I

³I am indebted to Dr. Claude Lambert of the Department of Orthopedic Surgery, College of Medicine, University of Illinois, for allowing me to participate in this clinic and to interview his patients.

TABLE I—continued
COMPOSITION OF FOUR GROUPS OF SUBJECTS

Reason for Amputation			Amputation Site										
Injury	Sarcoma	Other	'Leg'	Hip	Above Knee	Below Knee	Foot	'Arm'	Shoulder	Above Elbow	Below Elbow	Hand	Fingers ?
Largely no information			3	1	7	3		3	1	2	2	3	3
39	4	2		1	7	15	3		1	11	3	2	2
33	6	2		2	16	7			2	4	6	3	1
Largely to fit prosthesis					9	14	2			6			2

feel it now,'—'After you get used to it, you know it's gone but you have the feeling it is there,' etc.

When phantoms were not mentioned spontaneously at this time or during the account of subsequent events, the examiner said: 'Some people who have lost an arm (leg, etc.) have told me that it happens that they still feel the hand (fingers, toes, etc.) even though they know perfectly well that it is gone. Has it ever felt that way to you?' Thereupon some subjects immediately described their own phantom experiences, while to others this question did not seem to make much sense. Only rarely was the response indicative of a conscious denial, such as 'I don't think about it, I might have felt the toes but it's just your imagination, it is all in your head.' After a little reassurance, even these exceptional individuals usually came forth with quite vivid descriptions of their phantoms.

Once the phantom had been mentioned, either spon-

taneously by the subject or 'suggestively' by the examiner, and irrespective of the subject's reply to the latter, the interview continued. The examiner enquired in detail about the various parts which the subject experienced, their position, motility, pain, itching, etc., and he was asked also about incidents of 'forgetting' when he might have reached to grasp something with the phantom hand, or to steady himself, or when he might have stepped on the phantom foot and fallen. Such incidents were often reported spontaneously, and the subject was given free rein to describe his experiences. For the younger subjects it was often the parents who supplied these details or who, having heard about phantoms elsewhere, confirmed the child's indication of the presence or absence of phantoms by giving specific examples. In a few instances the parents recalled that the child had talked about phantoms soon after amputation, even though the youngster himself did not recall such experiences.

TABLE II
CASES OF PHANTOMS AFTER AMPUTATION IN CHILDHOOD REPORTED IN THE LITERATURE

Source	Amputation		Interview Age	Phantom
	Age	Site		
Souques and Poisot (1905) 'D'	2 mth.	Both hands	16 yr.	Absent
Browder and Gallagher (1948)	9 wk.	Arm	19 yr.	Absent
Cronholm (1951) Case 82	1 yr.	Right, above elbow	17 yr.	Absent
Critchley (1955)	1-6	?	3-6	Present
Cronholm (1951) Case 11	2 yr.	Right, above knee	18 yr.	Absent
Browder and Gallagher (1948)	2-6	Right arm and right leg	29 yr.	Absent
Steelman (1952)	3 yr.	Right arm	38 yr.	Absent
Browder and Gallagher (1948)	3-6	Right arm and left arm	45 yr.	Absent
Watson and Johnson (1958)	3-9	Right, above knee	3-9	Present
Cronholm (1951) Case 43	4 yr.	Left, below elbow	18 yr.	Absent
Cronholm (1951) Case 70	4 yr.	Right, below knee	18 yr.	Absent
Browder and Gallagher (1948)	4 yr.	Leg	?	Present
Cronholm (1951) Case 27	5 yr.	Right, above knee	24 yr.	Present
Riese and Bruck (1950)	6 yr.	Left leg	9+ yr.	Present ¹
Riese and Bruck (1950)	7 yr.	Finger	?	Absent
Riese and Bruck (1950)	7 yr.	Finger	?	Absent
Riese and Bruck (1950)	7 yr.	?	9+ yr.	Present ²
Cronholm (1951) Case 92	7 yr.	Left, below knee	31 yr.	Absent
Cronholm (1951) Case 6	7 yr.	Right, below elbow	16 yr.	Present
Ewalt <i>et al.</i> (1947)	7 yr.	?	40 yr.	Present
Souques and Poisot (1905) 'Beb'	7 yr.	Right, above knee	14 yr.	Present
Cronholm (1951) Case 17	8 yr.	Right, above elbow	17 yr.	Present
Cronholm (1951) Case 36	8 yr.	Right, below knee	16 yr.	Present
Cronholm (1951) Case 2	9 yr.	Left shoulder	14 yr.	Present
Cronholm (1951) Case 87	9 yr.	Bilateral, above knee	39 yr.	Present
Livingston (1945)	9 yr.	?	42 yr.	Present
Hécaen and Ajuriaguerra (1952)	9 yr.	Wrist	?	Present

¹Amputation at 6 yr. was not followed by a phantom until after surgical revision at 9 yr. when the phantom appeared.

²The phantom appeared spontaneously at age 9 yr., more than two years after amputation and without intervening surgery.

RESULTS

PHANTOM EXPERIENCES AFTER AMPUTATION OF PREVIOUSLY NORMAL EXTREMITIES The findings for the individuals in group a are presented in Table II, and those from group b in Table III. No such table is given for subjects of group c, since every individual of the group reported phantom experiences following amputation, experiences which persisted to the time of the interview in all but five cases. The results for groups a, b, and c, are combined in Table IV.

Table IV shows the general trend very clearly. Phantoms are reported for only a small proportion

of extremities lost before the age of 4 years; thereafter their incidence rises rapidly until phantoms follow predictably on amputation at or above the age of 8 years. The distributions for groups a and b are essentially alike, and the results of group c confirm the findings for the older subjects of groups a and b.

The reader may be surprised by the finding of any reports of phantoms following amputation in infancy and earliest childhood. Case 348 (Table III) at the age of 4 years and 3 months presents convincing evidence of a phantom foot following below-knee amputation at 6 months of age. The same was

TABLE III
PHANTOMS AFTER AMPUTATIONS OF NORMAL EXTREMITIES IN CHILDHOOD

Case No.	Amputation		Repeat Surgery (Gangrene, etc.)	Age at Interview	Phantom	
	Age	Site				
361	0-3	Left, above knee	None	5-7	Never	
301	0-5	Left, above elbow	At 5-0; 6-10	8-10	Never	
348	0-6	Right, below knee	(Thrombosis, gangrene preceding amputation)	4-3		Persisting
302	0-7	Right, above knee	No information	8-3	Never	
304	1-10	Right, above elbow	At least 6 revisions	6-0	Never	
303	2-1	Left, above elbow	None	9-4	Never	
372	2-4	Left, all fingers	None	19 yr.	Never	
305	2-7	Right, above elbow	At least 3 revisions	12-2	Never	
340	2-7	Right wrist	None	42 yr.	Never	
339	3-3	Right, above elbow	None	7-1	?	?
306	3-5	Left, above elbow	Gangrene pre-amputation	10-5		Persisting
307	3-10	Right foot	None	5-6	Never?	
901	4-2	Right, below knee	At 8 yr.; 10 yr.	25 yr.	Never	
308	5-1	Right, below knee	None	6-11	Never	
309	5-2	Right, above knee	None	13-10		Intermittent
310	5-4	Bilateral, below knee	Left only	14 yr.		Intermittent
311	5-4	Right, below elbow	No information	7-10		Persisting
312	5-6	Right, middle finger	Blood poisoning	60 yr.	Never	
313	5-10	Right, above knee	None	14-9		Non-persisting
528	5-11	Left, above elbow	At 15-11	16 yr.		Persisting
351	6-0	Left, mid-tarsal	(Chronic osteomyelitis)	17-8		Persisting
	(14-10)	Left foot				
	(15-0)	Left, below knee				
314	6-3	Right, above elbow	None	7-9		Non-persisting
335	6-5	Left forequarter	None	8-9		Persisting
315	6-8	Right, below knee	None	8-6	Never	
316	6-9	Right, below knee	Repeated revisions	10-3		Persisting
		Left, mid-tarsal				Persisting
395	6-10	Right, above knee	No information	20 yr.		Persisting
		Left, below knee				Persisting
317	7-6	Right, above elbow	No information	18 yr.		Persisting
380	7-6	Right, above elbow	No information	16 yr.	Never	
318	7-8	Right, below knee	At 8 yr.; 9 yr.	20 yr.		Persisting
347	7-11	Left hip, subtotal disarticulation	(Chronic drainage until re-amputation at 13 yr.)	13-9		Non-persisting
344	8-3	Left, below knee	At 21 yr. (gangrene)	22 yr.		Persisting
527	8-7	Right wrist	(Gangrene before re-amputation)	46 yr.		Non-persisting
	(8-10)	Right, below elbow				
358	8-8	Right, above elbow	At 10-1 (gangrene)	14 yr.		Persisting
393	9-0	Left, above knee	(Gangrene before amputation)	52 yr.		Persisting
319	9-6	Left foot	(Gangrene before amputation)	17 yr.		Intermittent
396	9-6	Left, above knee	(Osteomyelitis and gangrene before amputation)	51 yr.		Persisting
320	9-6	Left, below elbow	At 11-3 (gangrene and tetanus before amputation)	14-10		Persisting
334	9-6	Bilateral, below knee	None	10-4		Persisting
341	9-7	Right, below knee	At 9-8; 10-2; 12-10 (gangrene before amputation)	15 yr.		Persisting
321	9-10	Right, below knee	At 14-1	19 yr.		Intermittent
322	9-11	Left wrist	None	15-4		Persisting

apparently true of Critchley's case (Table II) with an amputation at 18 months who was seen at the age of 3½ years. An additional case of persisting phantoms after amputation at 18 months appears among the subjects with amputation of congenitally malformed extremities to be discussed below. From a statistical point of view these are exceptional cases, but in fact they may be crucial. One is tempted to speculate that these exceptions are really instances of a norm which can no longer be uncovered in the majority of infantile amputees, even though they may not persist as they do in the older amputee. Furthermore, both the phantom and the memory of

the phantom experience may be affected to a similar degree by the relative mnemonic instability of the very young. This hypothesis receives at least some support from a comparison of amputation-interview intervals for subjects who report phantoms and those who do not. Table V presents ranges and medians of these intervals. Evidently the distributions overlap considerably; yet, for amputations before the age of 8 years, the obtained difference is statistically significant (Mann-Whitney U test, $p = 0.01$).

PHANTOM EXPERIENCES AFTER AMPUTATION OF CONGENITALLY MALFORMED EXTREMITIES The detailed

TABLE III—continued

PHANTOMS AFTER AMPUTATIONS OF NORMAL EXTREMITIES IN CHILDHOOD

Comments

Occasionally complains of stump pain
Amputation followed severe burns. No details
Father: 'He knows he doesn't have it, but at times he says his foot hurts and he means the foot. He also talks about the stub (stump) but that's different'. Has pointed to foot of prosthesis, saying his foot hurt
Had never walked before receiving prosthesis at 2 yr. 10 mth.
Amputation two months after partial excision of tumour
Amputation five days after wringer injury
Knows of phantoms; remembers no such experience. Mother recalls no evidence of phantom
Amputation two weeks after mangle injury
Knows of phantoms; remembers no such experience. Older sister recalls no evidence
First interview, parents report no phantom. Subject agrees to 'suggestion' (?) that she can move her fingers; asked if she can make a fist, delays, 'tries', then says, 'Yes'. Asked to spread fingers, delays, 'tries', says she cannot. Is wearing prosthesis. On two later occasions, child and parents report, 'no phantom ever'
Sometimes feels as if he can open prosthetic hook just by spreading phantom fingers
Parents think amputation 'didn't register for a few days'. No other evidence of phantom
Student; has heard about phantoms, comments, 'It must be psychological'. Denial?
No evidence of phantom from subject or mother. Mother knows about phantoms
Felt whole leg until 6 or 7. Now only occasional itching of toes. No telescoping
Can always feel legs. However, feels them less vividly and less often than immediately after amputation. Right phantom foot faded before left ('the one I had the operation on')
Parents certain subject feels hand, can move fingers. Subject 'shows' how she wiggles fingers
Amputation two to three months after accident. Reliability of information questionable
Amputation three weeks after car accident. Mother reports vivid phantom for at least a few months after amputation. Subject apparently does not remember early phantom experience
Feels fingers and elbow. No telescoping
Vivid phantom after first amputation, gradually fading. Now feels toes at stump

Vivid phantom after amputation. Intermittent at 7-1. 'No feeling of fingers any more' at 7-9
Amputation 8-9 months after onset of swelling. Feels arm, elbow, hand—can move fingers
Mother knows about phantoms. Has asked subject repeatedly
Sometimes thinks he can 'get up and walk without artificial legs'. Feels feet and toes. Has fallen repeatedly

Feels right toes, left toes, and heel. Recently sat without prostheses, 'jumped up to walk', fell. When he first mentioned phantoms to family they thought he was crazy
Initially felt whole arm, now only thumb, at end of prosthesis. No telescoping
Reliability of report questionable due to low intelligence of subject and father
Feels foot, can move toes and ankle. 'Prosthesis feels like natural leg'
In hospital, 'I asked my mother to scratch my toes and she told me I didn't have the leg'. Phantom only for three to four weeks after amputation
'Still feels like I have the whole leg as long as I have the prosthesis on'
Phantom fingers and hand for about 2 yr. after amputation. Nothing now

Apparently felt elbow immediately after amputation, now only hand and fingers. No telescoping
Amputation two weeks after crushing injury. Feels toes, instep, sole. No telescoping
Foot in cast for six weeks between accident and amputation
Osteomyelitis, gangrene, high fever, severe pain for four weeks before amputation. Vivid phantom toes in stump ever since he can remember. No other phantom parts
Feels hand at stump. Can move fingers
Feels he can wiggle all toes. Toes at stumps, not in tips of prosthetic shoes
Amputation 17 days after car accident. Feels only toes at stump
On waking after amputation, 'Did not know the leg was off—leg felt numb'. Feels toes from time to time; can move them
Feels whole hand, all fingers. Sometimes they hurt or itch. Has tried to scratch them

TABLE IV
PHANTOMS, AFTER AMPUTATION IN CHILDHOOD IN GROUPS A, B, AND C

Age at Amputation (yr.)	Total Amputations	Phantoms Absent			Phantoms Present		
		a	b	%	a	b	%
<2-0	10	4	4	80	1	1	20
2-0 to 3-11	14	5	5½ ¹	75	2	1½ ¹	25
4-0 to 5-11	13	2	3	39	2	6	61
6-0 to 7-11	20	3	2	25	5	10	75
8-0 to 9-11	19	0	0	0	7	12	100
Group c							
10-0 to 19-11	41	—	0	0	—	41	100

¹Since the protocols for Case 339 (Table III) did not justify a definite decision, it has been entered as ½ in both columns.

TABLE V
AMPUTATION-INTERVIEW INTERVALS FOR 110 SUBJECTS¹

Age at Amputation (yr.)	Time Interval between Amputation and Interview					
	Phantom			No Phantom		
	N	Range	Median	N	Range	Median
<1-0	1	—	3-9	6	5-4 to 19 yr.	12-2
1-0 to 1-11	1	—	2-0	2	4-2 to 16 yr.	10-1
2-0 to 2-11	0	—	—	7	7-3 to 40 yr.	17 yr.
3-0 to 3-11	3	<1 mth. to 42 yr.	7-0	3	1-8 to 42 yr.	35 yr.
4-0 to 4-11	0	—	—	3	14 yr. to 21 yr.	17-6
5-0 to 5-11	7	2-6 to 19 yr.	8-8	2	1-10 to 55 yr.	26-5
6-0 to 6-11	7	1-6 to 13 yr.	3-6	1	—	1-10
7-0 to 7-11	6	5-10 to 33 yr.	9-9	2	8-6 to 24 yr.	16-3
Total <8-0 ²	25	<1 mth. to 42 yr.	8-8	26	1-10 to 55 yr.	16 yr.
8-0 to 8-11	5	5-4 to 38 yr.	9 yr.	0	—	—
9-0 to 9-11	13	0-10 to 43 yr.	7-6	0	—	—
10-0 to 19-11	41	0-2 to 60 yr.	2-6	0	—	—

¹For lack of complete information the following seven cases have been omitted from this table: From Table II, four cases of Riese and Bruck, one case of Browder and Gallagher, one case of Hécaen and Ajuriaguerra; from Table III, Case 339.

²Amputation-interview intervals were compared for 25 instances of phantom and 26 instances of no phantom after amputation before age 8 years. Mann-Whitney U = 448, z = 2.32, p = 0.01.

results for the subjects of group d are presented in Table VI, and have been summarized in Table VII.

The previously found relationship between age at amputation and incidence of phantom holds for this group of subjects just as it did for those discussed above. A quick comparison of Table IV and VII shows very similar percentages for the several age levels.

Group d, however, allows us to isolate a second factor, that of the sensory and motor function of the extremity before its loss. All those subjects who reported phantom experiences had had sensation and/or motion in the misshapen limb before its amputation. Conversely, two of the three subjects who reported no phantom following amputation after the age of 8 years had lacked such functions in the affected structure (Cases 468 and 467). Thus, the crucial determinant is not mere chronological age but the sensory-motor experience accumulated during the years which make up that age.

DISCUSSION

If we regard the amputation phantom as a legitimate member of the class of perceptual phenomena (and I tenaciously hold to that view) then our most general finding contributes little to our understanding of the phenomenon. What other perceptual development reaches a degree of completion anywhere between the ages of 6 months and 8 years? Had we found an absolute lower age limit, and a range extending over two or three years, we might have been able to correlate the emergence of the phantom with the emergence of some other specific perceptual acquisitions. For example, having established that phantoms follow predictably upon amputation at or after the age of 8 one might be tempted to recall the findings of Brunswik and his students concerning the development of the so-called perceptual constancies: in those experiments in which the constancies were shown to improve with age, the level attained around

age 7 or 8 years is usually that of the final adult performance, even though there may be additional improvement up to 10 or 12 years of age, which is followed by a drop during adolescence (Klimpfinger, 1933). Similarly, at 7 or 8 practically all normal children have attained the necessary stability and differentiation of perceptual functions to profit from instruction in reading and writing. True, many children are ready for these complex activities long before that age, but hardly at 6 months, or even at 18 months. Conversely, while the typical acquisitions at these early ages may be delayed somewhat in some children, they are never delayed for several years unless there is severe mental deficit, a condition which did not obtain in any of the subjects of this study. (It may however be of interest to note that, contrary to Pick's early claim, mental defective amputees appear to have normal phantom experiences (Pick, 1915; Simmel, 1959a)). An alternative hypothesis has been suggested, and received some support from the data on amputation-interview intervals. It is at least conceivable that even the very young amputee experiences a phantom transiently, an experience which typically does not persist and, in addition, cannot be recalled later. Both the transient nature of the young child's phantom and the forgetting of the experience may be due to a general instability of mnemonic processes at early ages. In addition, in so far as the distinction between reality and appearance presupposes even at the simplest level a degree of abstraction, and at least implicit verbal articulation, a phantom which had disappeared before these processes have been attained may simply lack any avenue of recall. Admittedly, this 'iceberg hypothesis' still does not account for the wide age range. It neither suggests why the phantom may, on occasion, not disappear in the very young amputee, nor why it disappears and cannot be recalled by some children having undergone amputation at a more advanced age, *e.g.*, above the age of 5 years (eight cases: three from Table II, four from Table III, and Case 902 from Table IV). In fact, this speculation can only be justified in negative terms; on the one hand, we know a bit about perceptual and conceptual development in the child, and the data do not fit in with that knowledge; on the other hand, we know nothing concerning the development of mnemonic processes and the determinants of forgetting, and where nothing is known, anything is possible.

From the subjects with amputations of congenitally malformed extremities we have learned that phantoms follow only if the limb had had some sensory or motor function before its loss. Even though we have only sketchy information concerning the extent of pre-amputation function and deficit, I

should like to suggest that the following two assumptions are more likely to be true than not:

1 When the subject is known to have walked before amputation, this implies that kinaesthesia was not completely absent in the affected extremity. It is suggested that this kinaesthetic sensitivity is probably the crucial parameter rather than the motor aspect of walking.

2 When there is sensory deficit, but not complete absence of sensation, it is unlikely that the several modalities are equally involved. It is highly probable that under those conditions the cutaneous modalities are most severely affected, or even absent, while kinaesthesia and deep pressure are less impaired, or perhaps even normal.

These two assumptions arise from as yet unpublished data which will be the subject of a future communication. Meanwhile, the reader is asked to consider them as at least reasonable hypotheses.

We can now return to the earlier hypothesis concerning phantoms after amputation in the very young. On other occasions I have argued that the phantom is a sign of a schema of the body which persists beyond the time of the loss of the limb (Simmel, 1956a and b, 1958). I have also argued that this schema is primarily a postural one, just as Head first suggested, and is built up largely from kinaesthetic and perhaps deep pressure experience (Simmel, 1960). The evidence for phantoms in at least some of the youngest amputees supports this view. At the early ages a visual or even a tactile schema of the body would seem to be precluded by the poverty of visual and tactile spatial organization. By contrast, the postural adjustments which the infant learns to make in the first few months may be regarded as evidence of the acquisition of a postural schema at that time, even though such a schema probably still lacks the fine articulation of later years which is probably largely dependent on the organization of tactile space.

SUMMARY

Data from several groups of young amputees indicate that phantoms are rarely reported if the amputation was performed before the age of 4 years; thereafter, their incidence increases, and phantoms follow predictably upon amputation at or above 8 years. Three subjects (four amputations) reported phantoms after amputation before the age of 2 years, the youngest being 6 months at the time of the surgery. It has been suggested that transitory phantoms may occur typically even in the very young amputees, that they may lack, however, the persistence of the adult phantom, and that the experience itself is forgotten. This hypothesis receives at least

TABLE VI

PHANTOMS AFTER AMPUTATION IN CHILDHOOD OF CONGENITALLY MALFORMED EXTREMITIES

Case No.	Amputation		Repeat Surgery	Age at Interview	Pre-amputation Function
	Age	Site			
416	2 hr.	Left, above elbow	None	11-0	None
384	17 days	Right, above elbow	Three revisions	5-6	None
451	2 mth.	Left, above elbow	No information	10-8	None
452	1-2	Right, below knee	At 3-10	12 yr.	Did not walk before amputation
453	1-5	Right, below knee	Three revisions	15 yr.	No foot motion; diminished sensation. Had walked
454	1-6	Left, below knee Right, above knee	None	11-9	Active crawling on knees
455	1-7	Right foot	Repeated	7-1	Normal (?) sensation; some motion
	3-5	Right, below knee	Revisions		
475	2-4	Right knee disarticulated	Repeated	4-8	Sensation bilateral 'pretty normal'
	4-1	Left knee disarticulated	Hip surgery		Some motion in both knees and arms
456	2-6	Left, below knee	Repeated fractures and grafts	11-8	In cast 0-2 to amputation except 1 month
					Probably diminished sensation
457	3-10	Right, above elbow	None	4-2	Normal (?) sensitivity; some elbow motion
476	4-?	Right finger residuals	None	7-10	Normal (?) sensation; no motion
469	5-4	Right, below knee	At 14 yr.	16 yr.	No information
458	5-4	Right, above elbow	Repeated surgery before and after amputation	9-11	No sensation in hand and forearm
466	7-0	Right, below knee	Surgery before and after amputation	9-3	elbow motion only
468	8-1	Right knee disarticulated	None	8-4	Walked
					No sensation; no motion
902	8-2	Right, below knee	No information	17-8	Normal sensitivity
459	9-0	Bilaterally above knee	No information	19 yr.	Sensation, perhaps diminished, crawled
460	9-5	Right, above knee	No information	18 yr.	Had walked
472	10-4	Left, below knee	Two revisions	23 yr.	Normal sensation, walked
461	10-6	Right, below knee	None	12 yr.	Had walked
471	11-1	Right middle finger residual	None	11-4	Sensitive to pain; no motion
462	11-4	Right, below knee	Repeated surgery before amputation	21 yr.	First walked at age 7
463	11-11	Left, below knee	Repeated surgery before amputation	14-2	Had walked
464	12 yr.	Right, above elbow	None	12-9	None
467	13-6	Bilaterally below knee	None	18 yr.	Sensation and motion present bilaterally
477	14-0	Right, below knee	None	15-4	Normal (?) sensation; had walked
903	14-1	Right, mid-tarsal	Repeated surgery before amputation	20-8	Walked; no sensory deficit
	14-4	Right ankle			
470	15-9	Left, above knee	At 19 yr.	19 yr.	Normal (?) sensation; had walked
473	17 yr.	Left, above knee	At 32 yr.	34 yr.	Normal sensation; had walked

TABLE VII

PHANTOMS AFTER AMPUTATION OF CONGENITALLY MALFORMED EXTREMITIES¹

Age at Amputation	N	No Pre-operative Function		Some Pre-operative Function		% Phantom
		No Phantom	Phantom	No Phantom	Phantom	
<2 yr.	8	4	0	2	2	50
2-0 to 3-11	3	0	0	2	1	33
4-0 to 5-11	2	0	0	1	1	50
6-0 to 7-11	1	0	0	0	1	100
8-0 to 9-11	5	1	0	1	3	75
10-0 to 19-11	11	1	0	0	10	100
Totals	No. 30	6	0	6	18	
	%	100	0	25	75	

¹For lack of adequate information, Cases 458, 462, 469 listed in Table VI, are omitted here.

TABLE VI—continued

PHANTOMS AFTER AMPUTATION IN CHILDHOOD OF CONGENITALLY MALFORMED EXTREMITIES

Phantom	Comments
Never	Thrombosis of arm; amputated immediately after birth
Never	Congenital vascular defect
Never	Arm gangrenous at birth, secondary to fracture
Never	Varus deformity of foot <i>et al.</i>
Never	Had used both legs actively for crawling, standing; walking 5 to 6 months before amputation
Persisting	Very intelligent and active. At age 3 complained briefly that her 'ankle hurt'. She can 'feel it when one of the other kids steps on my (artificial) foot. . . . Whenever I kick myself around the ankle I say "ouch". Protheses feel 'like real legs except when wearing tennis shoes.' Congenital malformation of both legs
Persisting	Leg in cast since 4 months. Had never walked before amputation; had stood on left leg only. Crawled actively on both knees
Never	Used both feet, primarily ankles, to push herself along in crawling; stood at 18 months. Hip surgery at 2-5 and 3-4 followed by casts. Mother has watched and asked child—no evidence of phantom
Never	Did not walk before amputation; crawled and stood with support. Reports phantom toes and heel. Sometimes 'forgets', steps, falls
Persisting	
Never	Some use of rudimentary forearm ending in single finger residual before amputation
Persisting?	Congenital hypoplasia of hand with boneless finger buds. Child insists he feels fingers. Intelligent parents never heard child talk about phantoms before; think child may respond to examiner's suggestion
Never?	Re phantom, mother says, 'She never had anything like that'. Child assents meekly. Same on repeat interview. Reliability? Denial?
?	Multiple congenital abnormalities. Gigantism of forearm. According to mother, no evidence of phantom. After many questions by nurses and physicians subject says he can feel hand. Suggestion? Reliability?
Persisting	In cast 2 to 14 months. Then walked in walking cast and/or elevated shoe. Feels toes only, at stump; can move them
Never	Spina bifida; flaccid paralysis of both legs. Child 'scooted around on stomach' since 10 months. Casts before amputation. Aunt reports before amputation, 'He knew about the legs only from seeing them'
Never	Had walked before amputation; probably no ankle motion. Pain one year before amputation. No phantom ever, according to intelligent patient and mother
Not-persisting	Crawled until age 6, then wheelchair. Vivid phantoms persisted for at least 2 years after amputation, none since
Persisting	Had walked on short leg with brace. Phantom toes at stump; can move them
Not-persisting	In walking cast until age 5, then brace. Felt toes only for several months after amputation, until fitted with prosthesis. No phantom since
Persisting	Toes and foot sometimes feel cramped, or may itch. Twice 'forgot' and almost stepped on phantom foot
Persisting	Finger residual amputated because it got in the way. Phantom finger feels the size of amputated residual. No phantom movement. Congenital absence of several fingers. No surgery, no phantom
Persisting	At 7 years walked with crutches, leg hanging down in cast; eventually walking cast. Feels toes only at stump. 'You know they're not there, but you feel they are'
Persisting	After amputation pain in absent leg. Now feels toes only, painless
Never	No phantom of amputated hand remnant nor of congenitally missing forearm
Persisting	Deformity of right foot; absence of left foot and toes. Now vivid phantom of right foot and toes; less vivid phantom of left lower leg. Very active; had walked, roller skated. Increasing pain and difficulty last year before amputation
Persisting	Feels foot; phantom toes are 'too little' and 'sticking out of the stump'. Has stepped on phantom foot and fallen
Persisting	Before amputation pes equinus. Feels foot and toes. No telescoping
Persisting	Feels toes, calf, knee. No telescoping. Increasing pain and difficulty last year before amputation
Persisting	Congenital elephantiasis of leg. Walked well; no casts, etc. 'Even to this day it feels like I could still move my large toe'

some support from a comparison of amputation-interview intervals. Such intervals were significantly shorter for subjects reporting phantoms than for those who did not. In a group of children who had undergone amputation of congenitally malformed extremities it could further be shown that phantoms occur only if there has been some sensory and/or motor function before the loss of the misshapen limb. It was suggested that the crucial variable here is kinaesthetic and/or deep pressure sensitivity. These findings were shown to support the hypothesis that the body schema which gives rise to the amputation phantom is basically a postural schema.

This report was prepared during the tenure of U.S.

Public Health Service Special Research Fellowship MF-1193 awarded to the writer by the National Institute of Mental Health. A supplementary grant from Brandeis University is gratefully acknowledged herewith.

REFERENCES

- Browder, J., and Gallagher, J. P. (1948). *Ann. Surg.*, 128, 456.
 Critchley, Macdonald (1955). *Encéphale*, 44, 501.
 Cronholm, B. (1951). *Acta psychiat. scand.*, Suppl. 72.
 Ewalt, J. R., Randall, G. C., and Morris, H. (1947). *Psychosom. Med.*, 9, 118.
 Guéniot (1861). *J. Physiol. de l'Homme et des Animaux*, 4, 416.
 Head, H., and Holmes, G. (1912). *Lancet*, 1, 144.
 Hécaen, H., and Ajuriaguerra, J. de (1952). *Méconnaissances et Hallucinations Corporelles*. Masson, Paris.
 Henderson, W. R., and Smyth, G. E. (1948). *J. Neurol. Neurosurg. Psychiat.*, 11, 88.

- Keynes, G. (1952). *The Apologie and Treatise of Ambrose Paré*. University of Chicago Press, Chicago.
- Klimpfinger, S. (1933). *Arch. ges. Psychol.*, **88**, 599.
- Livingston, K. E. (1945). *J. Neurosurg.*, **2**, 251.
- Melville, H. (1959). *Moby Dick*. Dell, New York, p. 507.
- Mitchell, S. Weir (1871). *Lippincott's Mag. pop. Lit. Sci.*, **8**, 563.
- Oldfield, R. C., and Zangwill, O. L. (1942a). *Brit. J. Psychol.*, **32**, 267.
- , — (1942b). *Ibid.*, **33**, 58 and 113.
- , — (1943). *Ibid.*, **33**, 143.
- Pick, A. (1915). *Neurol. Zbl.*, **34**, 257.
- Riese, W. (1958). In Poynter, F. N. L. *The History and Philosophy of Knowledge of the Brain and its Function: An Anglo-American Symposium*, 1957, p. 115. Blackwell, Oxford.
- , and Bruck, G. (1950). *Rev. neurol.*, **83**, 221.
- Russell, W. R. (1959). *Brain, Memory, Learning*. Clarendon Press, Oxford.
- Schilder, P. (1950). *The Image and Appearance of the Human Body*. International Universities Press, New York.
- Simmel, M. L. (1956a). *A.M.A. Arch. Neurol. Psychiat.*, **75**, 637.
- (1956b). *Amer. J. Psychol.*, **69**, 529.
- (1958). *Proc. Amer. Philos. Soc.*, **102**, 492.
- (1959a). *J. abnorm. soc. Psychol.*, **59**, 128.
- (1959b). *Amer. J. Psychother.*, **13**, 603.
- (1960). mimeo, Amer. Psychol. Ass. (to be published).
- (1961). *Amer. J. Psychol.*, **74**, 467.
- Souques and Poisot (1905). *Rev. neurol.*, **13**, 1112.
- Steelman, J. (1952). Personal communication.
- Watson, E. J., and Johnson, A. M. (1958). *Amer. J. Orthopsychiat.*, **28**, 85.

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