Experimental Demonstration of the Tomatotopic Organization in the Soprano (Cantatrix sopranica L.)*

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As observed at the turn of the century by Marks & Spencer (1899), who first named the "yelling reaction" (YR), the striking effects of tomato throwing on Sopranoes have been extensively described. Although numerous behavioral (Zeeg & Puss, 1931; Roux & Combaluzier, 1932; Sinon et al., 1948), pathological (Hun & Deu, 1960), comparative (Karybb & Szylâ, 1973) and follow-up (Else & Vire; 1974) studies have permitted a valuable description of these typical responses, neuro- anatomical, as well as neurophysiological data, are, in spite of their number, surprisingly confusing. In their henceforth late-twenties' classical demonstrations, Chou & Lai (1927a, b, c, 1928 a, b, 1929a, 1930) have ruled out the hypothesis of a pure facio-facial nociceptive reflex that has been advanced for many years by a number of authors (Mace & Doyne, 1912 ; Payre & Tairnelle, 1916 ; Sornette & Billevayzé, 1925). Since that time, numerous observations have been made that have tried to decipher the tangling puzzle as well as the puzzling tangle of the afferent and/or efferent sides of the YR and led to the rather chaotic involvement of numberless structures and paths : trigeminal (Loewenstein et al., 1930), bitrigeminal (von Aitick, 1940), quadritrigeminal (Van der Deder, 1950), supra-, infra-, and inter-trigeminal (Mason & Ragoun, 1960) afferents have been likely pointed out as well as macular (Zakouski, 1954), saccular (Bortsch, 1955), utricular (Malosol, 1956), ventricular (Tarama, 1957), monocular (Zubrowska, 1958), binocular (Chachlik, 1959–60), triocular (Strogonoff, 1960), auditive (Balalaïka, 1515) and digestive (Alka-Seltzer, 1815) inputs. Spinothalamic (Attoú & Ratathou, 1974), rubrospinal (Maotz & Toung, 1973), nigro-striatal (Szentagothai, 1972), reticular (Pompeiano et al., 1971), hypothalamic (Hubel & Wiesel, 1970), mesolimbic (Kuffler, 1969) and cerebellar (High & Low, 1968) pathways have been vainly searched out for a tentative explanation of the YR organization and almost every part of the somesthetic (Pericoloso & Sporgersi, 1973), motor (Ford, 1930), commissural

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(Gordon & Bogen, 1974) and associative (Einstein et al., 1974) cortices have been found responsible for the progressive building-up of the response although, up-to-now, no decisive demonstration of both the input and the output of the YR programming has been convincingly advanced.

Recent observations by Unsofort & Tchetera pointing out that "the more you throw tomatoes on Sopranoes, the more they yell" and comparative studies dealing with the gasp-reaction (Otis & Pifre, 1964), hiccup (Carpentier & Fialip, 1964), cat purring (Remmers & Gautier, 1972), HM reflex (Vincent et al., 1976), ventriloquy (McCulloch et al., 1964), shriek scream, shrill and other hysterical reactions (Sturm & Drang, 1973) provoked by tomato as well as cabbages, apples, cream tarts, shoes, buts and anvil throwing (Harvar & Mercy, 1973) have led to the steady assumption of a positive feedback organization of the YR based upon a semilinear quadristable multi-switching interdigitation of neuronal sub-networks functioning en désordre (Beulott et al., 1974). Although this hypothesis seems rather seductive, it lacks anatomical and physiological foundations and we therefore decided to explore systematically the internal incremental or decremental organization of the YR, allowing a tentative anatomic model.

MATERIALS AND METHODS

Preparation

Experiments were carried out on 107 female heal thy Sopranoes (Cantatrix sopranica L.) furnished by the Conservatoire national de Musique, and weighing 94–124 Kg (mean weight : 101 Kg). Halothane anesthesia was utilized during the course of tracheotomy, fixation in the Horsley-Clarke, and major operative procedures. 5% procaine was injected into skin margins and pressure points. Animals were then immobilized with gallamine triethyipdide (40 mg/kg/hr) and normocapnia was maintained by appropriate artificial ventilation. Spinal cord transections were performed at L^3/T^2 levels, thus eliminating blood pressure variations and adrenaline secretion induced by tomato throwing (Giscard d'Estaing, 1974). The fact that the animals were not suffering from pain was shown by their constant smiling throughout the experiments. Internal temperature was maintained at 38°C 4°F by means of three electrically driven boiling kettles.

Stimulation

Tomatoes (Tomato rungisia vulgaris) were thrown by an automatic tomato-thrower (Wait & See, 1972) monitored by an all-purpose laboratory computer (DID/92/ 85/P/331) operated online. Repetitive throwing allowed up to 9 projections per sec, thus mimicking the physiological conditions encountered by Sopranoes and other Singers on stage (Tebaldi, 1953). Care was taken to avoid missed projections on upper and / or lower limbs, trunk & buttocks. Only tomatoes affecting faces and necks were taken into account. Control experiments were made with other projectiles, as apple cores,

cabbage runts, hats, roses, pumpkins, bullets, and ketchup (Heinz, 1952).

Recording

Unit activity was recorded through glass-tungsten semi-macroelectrodes located au-petit-bonheur, according to the methods of Zyszytrazyczywsz-Sekrâwszliwcz (1974). Spike recognition was performed by audio-monitoring: every time a unit discharge was heard, it was carefully photographed, tapped, displayed on a monograph and, after integration on a polygraph. Statistical evaluation of the results was made using a tennis like algorithm (Wimbledon, 1974), that it, every time a structure responds up to win the game, it was recognized as YR-related.

Histology

At the end of the experiments, Sopranoes were perfused with olive oil, and 10% GlennFiddish, and incubated at 421°C in 15% orange juice during 47 hours. Frozen 2 cm unstained sections were mounted into —strawberry sherbet and observed under light and heavy microscopy. Histological verifications confirmed that all the electrodes were located in the brain except four that were found in cauda equina and filum terminale and disclosed from statistical analysis.

Results

Stereotaxic explorations of brains during tomato throwing showed that most of the areas respond differently to the tomesthetic stimulation. As can be seen from TABLE ONE, where the results are summarized, three (3) distinct

Regions	Tomatic stimulation					
	1/s	2/s	3/s	4/s	5/s	15/s
whole brain	0.0	0.0	4.2	0.6	0.7	000.1
raphé area	3.1	4.1	5.9	5.9	5.9	000.2
septum	±1	67	875	121	000	$_{\pi}$3517
thalamus	2.2	$\sqrt{3}$	456	±7	8.9	0.0001
NARTpl	456	+2	-4	§§	"2"	±0.001
hypothalamus	±"3	1&2	41	S.G	121	many
hippocampus	1/2	3%	$\sqrt{17}$	?	$<_{16}$	0± 7
cereb.cortex	*yes*	<55	*nsp*	{?}	±∞	71±70
scMS	~31	~65	>87	00†	345	a few
apTL	0.0	3.1	6.7	$\sqrt{4}$	--	56 %
amygdala	+3	± 3	3.3	333	\3	/3.33
N.Poissy	→8	0.0	→1	12←	M/5	1+1=2
N.Pesch	3§4	781	+2	+34	!	!!!!!
N.ruber	Λ51	???	$\sum_{4}^{3}$	$\int_{0}^{7}$	415	*maybe*

TABLE ONE. Differential responding of tomatic stimulation in the brain at different frequencies.

areas gave definite, unambiguous and constant responses : the nucleus anterior reticulalris thalami pars lateralis (NARTpl), or nucleus of Pesch (Pesch, 1876 ; Poissy, 1880, Jeanpace & Desmeyeurs, 1932), the anterior portion of the tractus leguminosis (apTL), lying 3.5 mm above the obex and 4 mm right of the tentorium and the dorsal part of the so-called "musical sulcus" (scMS) of the left hemisphere (Donen & Kelly, 1956). It is of interest to notice that, if the left hemisphere was kept for analysis the right hemisphere was left.

Examples of responses obtained from these structures can be seen on Fig. 1 where temporal analysis of the spike distribution based on their Responsive-Area-Temporal-Programming (RATP) properties allowed to distinguish 3 unit subtypes :1) units responding before the stimulation ; 2) units responding during the stimulation and 3) units responding after the stimulation.

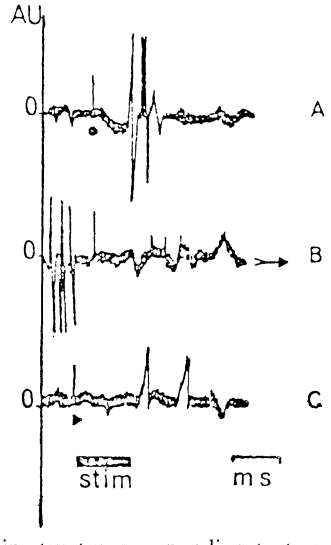

Fig. 1. Unit activity in structures responding to tomatic stimulation. Bar indicates stimulus onset & cessation. Calibration: 3.1416 ms. Each trace is made of the superimposition of 33.57 successive recordings. Note the point in A, the arrow in B and the black triangle in C.

Cross-examination of responses driven by other projectiles and Ketchup stimulation are shown on Figure 2 and argue unquestionably in favor of a tomatotopic organization of the YR along, between and across the NARTpl, apTL and scMS. Temporal relationships of those responses, as exemplified in Fig. 3, showed that the hypothesis of a clustering interdigitation of neuronal subnets is highly probable, although no experimental evidence can be given due to the relative difficulty of entering those destroying a lot of things (Timeo et al., 1971).

Discussion

It has been shown above that tomato throwing provokes, along with a few other motor, visual, vegetative and behavioral reactions, neuronal responses

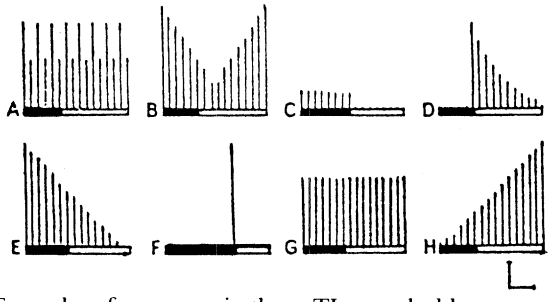

Fig. 2. Examples of responses in the apTL provoked by tomato and other throwings. Explanations in text. A = tomato; B = apple; C = cabbage; D = hats; E = roses; F = ketchupt; G = pumpkin; H = bullet.
† kindly provided by Laroche-Ciba, Inc.

in 3 distinctive brain areas : the nucleus anterior reticular thalami, pars lateralis (NARTpl), the anterior portion of the tractus leguminosus (apTL) and the dorsal part of the so-called musical sulcus (scMS). As pointed out by Chou & Lai (1929b), Lai & Chou (1931a, b) and Unsofort & Techtera (1972), the YR organization cannot simply reduced to an oligo synaptic facio-facial nociceptive reflex which would have relayed over in the fascia leguminosa of the VIth laminations of the ventral quadrants of the paleospino-rubro-yello-tecto-cerebello-nigrostriatal tomatonergic ascending pathways. For the fact that horseradish peroxidase injected into the Sopranoes' vocal cords is retrogradually transported from the apical dendrites of the vagus nerves to

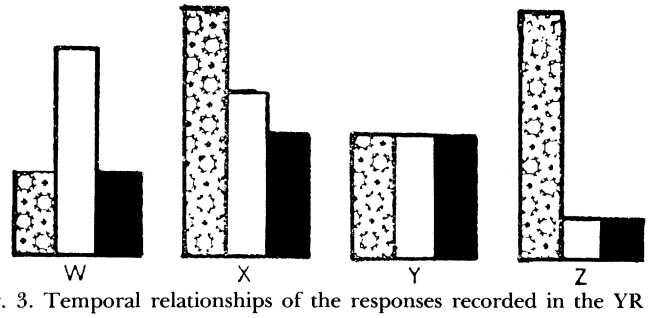

Fig. 3. Temporal relationships of the responses recorded in the YR area. Abscissae: arbitrary units; ordinates: international units. Explanation in text.

the tomato-tomatic synapses of the contralateral pseudogasserian afferents (McHulott et al., 1975) proves with some likelihood the leguminous nature of the mediator responsible for the transmission of the message from the receptive tomato fields to the YR circuitry (Colle et al., 1973). Thus, 3,5 (M-Tri) argyril-L-tomatase which is selectively trisynthetized in the NARTpl-apTL bundle and whose destruction blocks up drastically the YR (Others et al., 1974) stands out as the major candidate for the transmitter involved in the YR retroacting loop, although an alternate hypothesis based upon latency calculations, and co-cross frequency correlations, puts forward the feasibility of a tomatotonic synapse (see Dendritt & Haxon, 1975). Although decisive

experimental evidences are still lacking and further series of experiment are needed before the complete elucidation of the YR can be achieved, it seems logical to advance that above combined arguments along with experimental results described in our work are likely to support the hypothesis of a semi-linear multi-stable multi-switching net-back feed-work organization of the YR whose a tentative anatomical model can therefore be proposed (Fig. 4).

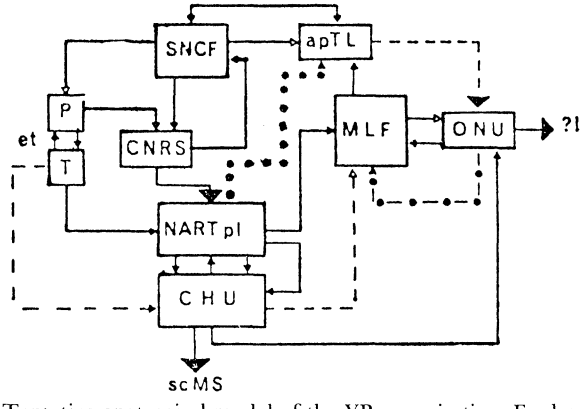

Fig. 4. Tentative anatomical model of the YR organization. Explanations in text or elsewhere. Black lines = inhibitory; broken lines = interrogatory; dashed lines = redhibitory; stellate lines = whig-and-tory.

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Sommaire:
Démonstration expérimentale d'une organisation tomatotopique chez la Cantatrice.

L'auteur étude les fois que la lancement de la tomate il provoquit la réaction yellante chez la Chantatrice et demonstre que divers plusieures aires de la cervelle elles était implicatées dans le response, en particular le trajet légumier, les nuclei thalameux et le fiçure musicien de l'hémisphère nord.

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