"off" responses at all points within their borders.

We believe these observations exclude simple explanations of movement sensitivity in terms of pooled effects from "on" and "off" zones of the receptive field. Exploration with a stationary spot turned on and off, and noting the phase at which a discharge occurs, does not provide a sufficient basis for predicting the response to a moving spot. In addition it is clear that two synaptic layers can abstract direction of motion from the spatio-temporal pattern of light falling on the retina, and that the rabbit possesses such a system of directionally selective ganglion cells in its retina (*10*).

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Bonding in Xenon Fluorides and Halogen Fluorides

Abstract. *The bonding in rare gas fluorides is similar to that in halogen polyfluorides, and the stability of such compounds should depend primarily on the ionization potential of the central atom. This theory is consistent with findings for all known compounds of the system and yields predictions concerning other systems.*

The very interesting discovery of stable xenon and radon fluorides (*1*) raises questions concerning the nature of the chemical bonding in these molecules. Two notes have been published on this topic (*2*), but neither offers a criterion of stability for rare gas fluorides, nor do they consider the various interhalogen compounds, such as BrF_5, which should be closely related to rare gas fluorides. Since there may be real advantage in considering these two types of molecules at the same time, further discussion seems desirable.

The properties of the interhalogen compounds have been reviewed recently (*3*), hence only a few of the most pertinent features are mentioned here. The diatomic species such as ClF have normal electron pair bonds and may be considered analogous to the rare gas atoms in that their normal valence shells are filled. It is the bonding of additional fluorine atoms to the chlorine of ClF to yield ClF_3 (or to yield BrF_3 or BrF_5 from BrF) (*4*) that is analogous to the formation of XeF_2 and XeF_4.

The structures of ClF_3, BrF_3, BrF_5, and IF_5 all show a pattern of approximately 90- and 180-degree bond angles with one especially short X—F bond and one or two pairs of linear three-atom arrays, $F-X-F$, with slightly longer X—F distances. The result is a planar T-shaped structure for the XF_3 and a square pyramid for the XF_5 molecules, respectively. These structures are readily explained by dsp^3 and d^2sp^3 valence shells for the central atom, with the two and the one position occupied by unshared electron pairs, respectively, for XF_3 and XF_5. However, the data on the nuclear quadrupole coupling indicate that the central atoms have a substantially smaller electron population than would be expected for covalent bonds on this pattern (*5*).

Since the fluorine nucleus has no quadrupole moment, one cannot apply this method of determining electron population to the terminal atoms in the fluorides, but it has been applied in the case of the iodine chloride molecules and ions. Cornwell and Yamasaki (*6, 7*) have shown that in the series ICl, ICl_2^-, ICl_4^-, the chlorine atoms carry a substantial negative charge (over 1/2 *e* in the negative ions), while the iodine atoms are correspondingly positive. These results, which follow from the *p*-orbital populations, as determined by the quadrupole-coupling results, account quite well for the electron population, leaving at most a small participation of *d* orbitals for these compounds.

There seems every reason to expect that the more electronegative fluorine atoms are similarly negative and that the bonding pattern proposed by Yamasaki and Cornwell (*7*) for the iodine chlorides is applicable equally to the halogen fluorides and the xenon fluorides. In this pattern there are two molecular orbitals involved in the bonding of each linear array of three atoms (for example, F—Br—F or Cl—I—Cl). The first molecular orbital is composed of the central-atom *p* orbital along the particular axis, together with the antisymmetric (bonding) combination of terminal-atom σ orbitals. The second molecular orbital is composed primarily of the symmetric combination of terminal-atom σ orbitals and has only very small components of central-atom *d* or *s* orbitals. It is evident that the filling of these two molecular orbitals yields essentially a half covalent bond and a half ionic bond for each linkage.

Table 1. Ionization potentials of the atoms of interest and the fluorides reported to form in each case.

Atom	Ionization potential (ev)	Fluorides formed
I	10.44	IF, IF_5, IF_7
Br	11.84	BrF, BrF_3 BrF_5
Xe	12.13	XeF_2, XeF_4
Cl	13.01	ClF, ClF_3
Kr	14.00	

Let us now consider the process in which an array F—X—F is formed from X (for example, ClF or Xe) and F_2. The net energy change may be written as

$$\Delta E = I(X) - E(\mathrm{F}) + D(\mathrm{F_2}) - B(\mathrm{F} - X - \mathrm{F}) \quad (1)$$

Here, I is the ionization potential of X, E is the electron affinity of F, D is the dissociation energy of F_2, and B is the binding energy of F—X—F formed from $X^+ + F^- + F$. B contains effectively the electrostatic energy of the ionic bond, together with the covalent bond energy diminished by any nonbonded repulsive terms. The two middle terms in ΔE do not depend on X at all, and it seems unlikely that the dependence of B on X is very great (*8*). Consequently, we may expect that $I(X)$ will be the factor which effectively decides whether or not these F—X—F linkages are stable.

Table 1 gives the ionization potentials of the atoms of interest, together with the fluorides reported to form in each case. It is interesting to note that for the reaction $XF_3 = XF + F_2$ the literature values (*3*) for ΔH are 1.1 ev for ClF_3 and 2.1 ev for BrF_3. The difference of 1.0 ev is close to the difference in ionization potential (1.17 ev), as expected from our theory. It is apparent, on this basis, that xenon fluorides should be stable, and we may even predict that the enthalpy of dissociation of XeF_2 to $Xe + F_2$ lies between the ΔH values given above for the reactions of BrF_3 and ClF_3. Similarly, we may expect the enthalpy of the reaction $XeF_4 = Xe + 2F_2$ to be somewhat less than the 4.6 ev found (*3*) for $BrF_5 = BrF + 2F_2$.

Since the ionization potential of krypton is about 1 ev higher than that of chlorine, and since ΔH for the reaction $ClF_3 = ClF + F_2$ is only 1.1 ev, the ΔH of dissociation of any krypton fluoride is expected to be about zero, at best. Also, the entropy of dissociation of any complex fluoride will be positive, hence krypton fluorides are predicted to be thermodynamically unstable under low-pressure conditions, but might be prepared by indirect methods.

The corresponding energy expression for the five atom units

$$\begin{array}{ccc} & F & \\ F & X & F \\ & F & \end{array}$$

is essentially similar to Eq. 1 for $F—X—F$, but it involves also the second ionization potential of X and a larger ionic bonding term as well as a coefficient of 2 for the other terms in Eq. 1. Detailed calculations indicate that, for the elements under discussion, the boundary of stability is essentially the same for the XF_4 unit and for the XF_2 unit. The $F — F$ nonbonded exchange repulsions would be relatively more numerous in the XF_4 unit and larger, because of the shorter distances, in chlorine fluorides than in the other cases; this may account for the absence of a stable ClF_5.

The bonding in compounds such as ClO_2 or ClO_4^- is also partially ionic and partially covalent. Consequently the ionization potential of the central atom is expected to be a good indicator of stability of oxides of this type. Since the ionization potential of xenon is less than that of chlorine, attempts to produce xenon oxides seem to be indicated and are being made in this laboratory. Xenon oxyfluorides have been reported (*1*). It should be noted that most of the oxy-chlorine compounds are thermodynamically unstable with respect to the evolution of oxygen, whereas ClF_3 is stable with respect to the evolution of fluorine. Thus, indirect methods of preparation may be required for xenon oxides, and such compounds, even if formed, may be unstable and possibly explosive.

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8. The ionic term is determined by the bond distances, which are nearly constant: Cl — F is 1.70 Å; Br—F is always near 1.81 Å; I—F in IF_5 is reported to be approximately 1.75 Å, but I—F is probably at least as long in IF_5 as in BrF_5. The covalent bond energies in the series ClF, BrF, IF are likewise nearly constant: 60.3, 59.4, and 66.2 kcal, respectively.

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Word Association: Common and Original Response

Abstract. *The scoring of popular responses in the word-association test provides only a fair estimate of the number of original responses. The magnitude of the relationship between popular and original responses will be overestimated unless one employs a correction for the constraint imposed by one score on the other. Two methods of correcting for the lack of independence between the numbers of popular and of original responses are described.*

In 1910, Kent and Rosanoff selected 100 common English words (none of them especially likely to provoke socially dubious responses) as stimuli; presented the words verbally to 1000 "normal men and women"; and recorded their verbal responses (*1*). Scoring the association-test results only for "individualistic" responses (that is, responses made only once), Kent and Rosanoff found that the percentages of individualistic responses for different groups were as follows: for "normal persons with only common school education," 5.2; for college-educated subjects, 9.3; and for some schizophrenic patients, 25 to 50. Individualistic responses have been of interest to psychologists studying many different aspects of thinking and problem solving. MacKinnon, studying creativity among architects (*2*), "found the unusualness of mental associations one of the best predictors of creativity."

Table 1. Correlation coefficients for the three indices of the relationship between popular and original responses.

Correction method	Combined ($N = 56$)	First test ($N = 28$)	Second test ($N = 28$)
Uncorrected	−.88		
Odd-even:			
Populars$_{odd}$ versus originals$_{even}$	−.74	−.76	−.71
Populars$_{even}$ versus originals$_{odd}$	−.74	−.75	−.80
Proportion	−.78	−.78	−.79

While investigators in a number of areas are interested in idiosyncratic, novel, improvisatory, or original behavior, it is obviously very time-consuming and laborious to score a test for rare responses. In the case of the stimulus word *Needle* in the word association test, one would have to run through from 45 to 60 responses in order to determine that the response being scored is truly of the one-in-a-thousand variety. Woodworth and Schlosberg assure us that the much easier task of scoring only the most common response to each stimulus word provides an inverse measure of rarity; however, they do not cite evidence in support of this assertion (*3*).

Woodworth may have reached that conclusion after seeing correlation coefficients computed from a comparison of gross numbers of popular and of original responses (*4*). Such a procedure would yield a spuriously large negative correlation, for the number of popular responses limits the number of original responses that are possible; one could not possibly give a large number of popular responses *and* a large number of original responses. One can correct for this lack of independence of the two measures by determining, for each subject, the proportion of responses that are popular responses and correlating that value with the proportion of the remaining responses that are original responses [that is, compute the correlation r between $P/100$ and $O/(100 - P)$]. Another method of correction resembles the split-half method of computing test reliability. It is conceptually different from the proportion-correction method, but the two yield similar estimates of the true relationship. Correlation coefficients obtained