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Gray's Reinforcement Sensitivity Theory: a psychometric critique

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Abstract

This study identifies valid orthogonal scales of Gray's animal learning paradigms, upon which his Reinforcement Sensitivity Theory (RST) is based, by determining a revised structure to the Gray–Wilson Personality Questionnaire (GW PQ) (Wilson, Gray, & Barrett, 1990). It is also determined how well Gray's RST scales predict the surface scales of personality, which were measured in terms of Eysenck Personality Profiler (EPP) scales, the EPQ-R and the learning styles questionnaire (LSQ) scales. First, results suggest that independent pathways of RST scales may exist in humans. Second, Fight seems related to Anxiety and not the Fight/Flight system as proposed by RST. Third, a remarkably consistent story emerges in that Extraversion scales are predicted by Fight, Psychoticism scales are predicted by Active-avoidance, Fight and/or Flight, and Neuroticism scales tend not to be predicted at all (except for Anxiety). Fourth, Gray's revised scales are unrelated to gender and age effects and show a predictable overlap with the LSQ and original GW PQ scales. It is concluded that Gray's model of personality might provide a stable biological basis of many surface scales of personality, but that there must also be other influences on personality. These results question the finer structure of Gray's RST whilst also showing that RST has greater range of applicability than a strict interpretation of theory implies. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Eysenck; Gray; RST; EPQ; EPP; GW PQ; LSQ; Basis of personality

1. Introduction

Gray's (1982, 1987) Reinforcement Sensitivity Theory (RST) is a biological based model that also has a basis in animal learning paradigms. Implicit in RST is that it is at least a partial *cause of personality* (e.g. Corr, 2001; Gray, 1970; Matthews & Gilliland, 1999). The model consists of:

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(a) The Activation (or Impulsivity) system which consists of appetitive response to reward (Approach) and active response to punishment (Active avoidance). This system is associated with pleasurable emotional states which are highly sensitive to reward. Gray's theory suggests that highly impulsive people learn best from, and are motivated by, reward. (b) The Inhibition (or Anxiety) system which consists of reducing the risk of punishment by inactivity and submission (Passive avoidance) and abandoning behaviours that are not rewarded (Extinction). People with heightened reactivity to the inhibition system are sensitive to fear and punishment, and therefore high scorers on anxiety are thought to learn best from, and be motivated by, punishment. (c) Rapid escape from sources of punishment (Flight) and defensive aggression (Fight). The third scale labelled Fight/flight (FFS) is less well understood (Corr, 2001; Matthews & Gilliland, 1999). From the biological perspective, the Impulsivity and Anxiety systems are most often stated to be a 45 degree rotation of Eysenck's (1967) biological model of personality, but recent clarification suggests that Impulsivity is aligned at 30 degrees to Extraversion, and Anxiety is aligned at 30 degrees to Neuroticism (Corr, 2001; Pickering, Corr, & Gray, 1999). Impulsivity has a biological basis in the Behavioural Activation System (BAS), and Anxiety has a basis in the Behavioural Inhibition System (BIS).

Corr (2001) raises the question of how much overlap could be expected between the scales of the RST. Most studies to date seem to assume that the BIS and BAS systems are independent of each other and form separate systems, but this has yet to be tested psychometrically in humans.

Recently the Gray–Wilson Personality Questionnaire (GWPQ) has been used as a measure of Gray's RST (Wilson, Barrett, & Gray, 1989; Wilson, Gray, & Barrett, 1990). The GWPQ was designed to measure the three main mechanisms of Gray's model (BAS, BIS and FFS) and the two animal learning paradigms associated with each of the main mechanisms. Results of various studies tend to suggest that the GWPQ seems able to identify activation and inhibition systems, but does not reflect the full depth of Gray's theory (Jackson, 2002; Slobodskaya, Safronova, Knyazev, & Wilson, 2001; Wilson et al., 1989, 1990; Wilson, Barrett, & Iwawaki, 1995). Jackson (in press) reported that there was some consistency in activation and inhibition predictors of the primary scales of the Eysenck Personality Profiler¹ (EPP; Costa & McCrae, 1995; Eysenck, Barrett, Wilson, & Jackson, 1992; Jackson, Furnham, Forde, & Cotter, 2000), but that in general the ability of the GWPQ to predict scales of the EPP was relatively poor.

Examination of the GWPQ and its associated scoring suggests that the items seem generally related to the idea of reward and punishment in humans, but that some load on several scales and some are not clearly related to the authors' choice of scale. In this study, the items of the GWPQ are analyzed with the aim of identifying items that load on just *one* scale. In doing this, it seems that it might be possible to produce a psychometrically useful tool which properly reflects the six mechanisms described by Wilson et al. (1990), or provide guidance on how such a tool might be better designed. If the six mechanisms are at least partly the causal basis of personality then it would be of great interest to relate them to the primary scales of the EPP and the scales of the EPQ-R, which might easily be thought of as the surface scales of personality.

Corr (2001) explains that a strict interpretation of RST suggests that BIS and BAS are sensitive only to conditioned stimuli, and therefore are *not* supposed to be related to Pavlovian conditioning or procedural learning. The FFS, which is sensitive to unconditioned stimuli, could be expected to be related to Pavlovian conditioning. Nevertheless, Corr (2001) reports that Gray's

¹ The Eysenck Personality Profiler is available from the author.

RST does seem to explain variance in procedural learning and therefore argues that RST has a more general effect on processes of general arousal and emotion that lead to profound effects over the whole ‘cognitive-behavioural landscape’ (p. 338) to a far greater extent than a strict interpretation of theory would imply.

Experiential learning (Kolb, 1984) seems different to procedural learning and it is therefore interesting to determine the extent that RST might predict this form of learning. Experiential learning describes the learning process in terms of four stages: (1) activists who thrive on the challenge of new experiences; (2) reflectors who observe and ponder on what they have experienced; (3) theorists who enjoy the process of integrating these observations into a theoretical framework; and (4) pragmatists who are more interested in testing the theory through practical application. Experiential learning is commonly measured by Honey and Mumford’s (1992) Learning Styles Questionnaire (LSQ) and validity of the LSQ is established and reviewed by Furnham, Jackson, Forde, and Cotter (2001) and Furnham, Jackson, and Miller (1999). Jackson (2002) determined that experiential learning seemed to offer little new variance to RST in explaining the surface scales of personality. In line with Corr (2001), I expect that RST will predict scales of experiential learning, even though this is not predicted from a strict interpretation of RST.

The aims of the study are as follows. To:

1. determine what we can learn about the items of the GWPQ and why the GWPQ does not seem to have the factor structure proposed by the authors (Wilson et al., 1990); identify items that load on just *one* scale;
2. determine if an orthogonal factor structure can be obtained which would suggest RST systems which can work independently;
3. use these revised scales to determine if Gray’s model of personality can predict surface scales of personality as measured by the EPP and the EPQ-R; and
4. determine the degree of overlap between RST and experiential learning, as measured by Honey and Mumford’s (1992) Learning Styles Questionnaire (LSQ). Large overlap would indicate that Gray’s RST has a broader utility than a strict interpretation of the theory would imply.

2. Method

2.1. Participants

Two groups participated in this study. They are already described by Jackson (2002) who reported relationships using the original GWPQ scales. Each group received different questionnaires:

2.1.1. Group 1

A total of 70 participants took part in this study (51 males and 19 females respectively). All were employees of a Graduate Development Programme of a highly successful ‘blue-chip’ company in the City of London. The ages of participants ranged from 21 to 28 years, the mean age being 23 years.

2.1.2. *Group 2*

One hundred participants from the University of Surrey and the surrounding area were used in this study. They comprised of 36 males and 64 females and were from varied backgrounds including students, recruitment consultants and secretaries.

2.2. *Measures*

2.2.1. *Group 1*

The following questionnaires were administered to Group 1:

1. Learning Styles Questionnaire (LSQ; Honey & Mumford, 1992);
2. EPQ-R short scale (Eysenck & Eysenck, 1991);
3. Gray–Wilson Personality Questionnaire (GWPQ);
4. Anxiety—the EPP scale of Anxiety (Eysenck & Wilson, 2000); and
5. Impulsiveness—the EPP scale of Impulsiveness (Eysenck & Wilson, 2000).

2.2.2. *Group 2*

The battery of questionnaires administered to this group consisted of three different personality questionnaires:

1. the LSQ;
2. the GWPQ; and
3. all scales of the EPP.

2.3. *Procedure*

Questionnaires were distributed by hand and participants completed each of the questionnaires. Participants were fully debriefed on the aim of the study and offered individual feedback on their results. Participants in Study 1 were additionally told that the study was for survey purposes only.

3. **Results**

The multiplicity of problems in the design of the GWPQ must have been immense as it is clearly very hard to translate simple animal learning mechanisms into items representative of human behaviour. Item analysis (not presented here; but available upon request) suggests that many items load on more than one scale. This has the consequence that the scales are themselves intercorrelated, with the result that it is only possible to extract general Activation and Inhibition factors from the original questionnaire.

The item analysis conducted in this study focussed, first, on identification of items that generally correlated with just one scale total; and then second, on improving the choice of items by means of factor analysis with varimax rotation to ensure orthogonality of resultant factor structure. In doing this, I was aware that there was likely to be a large loss of items, but suspected that

an orthogonal structure might present a chance to study the possibility that there may be core contents of RST scales which are independent of each other.

After the first stage of the process outlined above, 49 items that correlated on just one GWPQ scale were identified and the other items were rejected. Then, by means of exploratory factor analysis (maximum likelihood with varimax rotation, six-factor solution imposed, $N = 170$), items with factor loadings on more than one factor, or on no factor, were identified and then removed. Reference to the original item loadings suggested by Wilson et al. (1990) was made for clarification and assistance in the process, but where the case of an item loading on a different scale seemed clear both in terms of the psychometrics and theoretical rationale then this was accepted. The resulting solution is shown in Table 1.

Table 1
Factor analysis of the key items of the GWPQ

	I FL	II FI	III AA	IV PA	V AP	VI EX	Rationale
% Var	7.5	7.5	5.1	5.0	4.8	4.0	
Cum % Var	7.5	15.0	20.1	25.1	30.0	33.9	
Mean	7.8	3.9	6.2	0.8	1.4	3.5	
SD	3.1	2.6	3.0	1.3	1.4	1.9	
Alpha	0.65	0.67	0.50	0.65	0.46	0.47	
GW114			−0.39				Not Active avoid a fight
GW74			−0.56				Not Active avoid a fire
GW67			0.27				Active avoid expense
GW23			0.48				Active avoid losing voice
GW80			0.26				Active avoid boss displeasure
GW107			0.23				Active avoid effort
GW19			0.28		−0.34		Refuse to Approach food
GW13					0.92		Approach food
GW6	0.48						Not do Flight from danger
GW24	−0.52						Panic flight from danger
GW30	0.78						Calm in face of danger
GW120	−0.42						Flight from danger
GW118	−0.42						Flight from embarrassment
GW4	0.26						Not do Flight from embarrassment
GW1						0.41	Extinction of previous job
GW94						0.40	Extinction of using phone
GW106						0.63	Extinction of asking
GW87			0.61				Passive Avoid unhappy memories
GW93			−0.83				Enjoy happy memories
GW29	0.83						Fight back
GW35	−0.64						Not fight back
GW65	0.37						Fight back
GW89	0.50						Fight back

Varimax rotation used to achieve orthogonal solution. Factor loadings below 0.25 are not shown, except for the key loading of GW107 on AA. GWPQ=Gray–Wilson Personality Questionnaire, GW are items from the GWPQ. FL = Flight, FI = Fight, AA = Approach avoidance, PA = Passive Avoidance, AP = Approach, EX = Extinction.

Interestingly, items seem to have quite a different loading to those predicted by the original authors and very few items remain from the original 120. However, the factor analysis is supported by a consistent rationale to the items (both a priori and post hoc) that is also shown in Table 1 and by the clear orthogonal structure to the items. General lessons apparent from this exercise can be summarized:

1. Some items thought to be Extinction oriented are as much related to Flight items (e.g. GW118: Would you pull out of an amateur dramatic production if you were having trouble learning your lines?)
2. Passive avoidance items are also related to Flight (e.g. GW 75. Do you take it to heart and 'fall to pieces' if somebody criticizes you?). Only memory items (as shown in Table 1) load on a scale of passive avoidance that is separate to flight.
3. Approach items are difficult to separate from Active avoidance items. The only ones that form a separate scale are those to do with obtaining primary needs such as food (as shown in Table 1).
4. Fight items form a separate scale only when concerned with a direct response to violence. Other fight items (such as GW. 113. Have you ever felt like killing somebody?) do not just load on the Fight scale.

Alpha reliabilities of the resultant scales ranged from 0.47 to 0.67 and were thus moderate to satisfactory. Alpha coefficients of the original scales with many more items were, however not much higher and were reported by Wilson et al. (1990) to be in the range of 0.60–0.70.

It is also possible to determine how well the revised GWPQ scales predict other scales. As the GWPQ scales are orthogonal, correlations provide a clear summary and as good a statistical methodology as multiple regression (see Table 2). Since some of the revised GWPQ scales have relatively low reliability, corrections for attenuation are also provided. It should be noted that correlations corrected for attenuation provide a theoretical maximum and should not be over-interpreted.

First, the correlations of the revised GWPQ scales with the original GWPQ scales can be examined. Following the work of Campbell and Fiske (1959), correlations show good convergent validity with the original scales of the same name (vary between $r=0.44$ and $r=0.77$) and have discriminant validity in that they do not correlate with the original scales of different names (except for the revised Active avoidance scale which is more highly correlated with the original scale of Approach, than the original scale of Active avoidance).

The revised scales are also correlated with the Impulsivity, Anxiety and Aggressiveness scales of the EPP. Here the revised scales strongly follow the expected structure: Active avoidance and Approach correlate with Impulsivity; Extinction and Passive avoidance correlate with Anxiety, and Fight correlates with Aggressiveness. Approach avoidance also correlates somewhat with Aggressiveness, and unexpectedly Flight strongly correlates with Anxiety, and not with Aggressiveness.

None of the revised scales are correlated with sex or age which suggests equivalence across sex and stability across age.

Finally, the revised GWPQ scales were correlated against the EPP primary scales and the scales of the EPQ-R. Consistently, Extraversion primary scales are predicted by Fight, Psychoticism

Table 2

Correlations of factor scores with other scales (correlations in italics are corrected for attenuation)

	Revised GWPQ Scales											
	Imp				Anx				FFS			
	AA	<i>(AA)</i>	AP	<i>(AP)</i>	EX	<i>(EX)</i>	PA	<i>(PA)</i>	FL	<i>(FL)</i>	FI	<i>(FI)</i>
(a) Original scales												
AA	0.44**	<i>0.79</i>	-0.30**	<i>-0.56</i>	-0.16*	<i>-0.30</i>	-0.10	<i>-0.16</i>	0.07	<i>0.11</i>	-0.19*	<i>-0.29</i>
AP	-0.50	<i>-0.85</i>	0.41**	<i>0.73</i>	0.21**	<i>0.37</i>	0.02	<i>0.03</i>	0.20**	<i>0.30</i>	0.27**	<i>0.40</i>
EX	0.17*	<i>0.29</i>	0.00	<i>0.00</i>	0.52**	<i>0.93</i>	0.19*	<i>0.29</i>	0.44**	<i>0.67</i>	0.11	<i>-0.16</i>
PA	-0.06	<i>-0.10</i>	0.02	<i>0.04</i>	0.28**	<i>0.49</i>	0.50**	<i>0.74</i>	0.47**	<i>0.70</i>	0.07	<i>-0.10</i>
FL	-0.02	<i>-0.03</i>	0.06	<i>0.10</i>	0.25**	<i>0.42</i>	0.15*	<i>0.22</i>	0.72**	<i>1.04</i>	0.04	<i>0.06</i>
FI	-0.30**	<i>-0.49</i>	0.06	<i>0.10</i>	0.15	<i>0.25</i>	0.21**	<i>0.30</i>	0.15	<i>0.21</i>	0.77**	<i>1.09</i>
(b) EPP Analogous scales												
Imp	-0.42**	<i>-0.68</i>	0.27**	<i>0.46</i>	0.05	<i>0.08</i>	-0.01	<i>-0.01</i>	0.05	<i>0.07</i>	0.13	<i>0.18</i>
Anx	-0.06	<i>-0.09</i>	0.16*	<i>0.26</i>	0.31**	<i>0.50</i>	0.22**	<i>0.30</i>	0.47**	<i>0.64</i>	-0.03	<i>-0.04</i>
Agg	-0.25*	<i>-0.43</i>	0.03	<i>-0.05</i>	0.08	<i>0.14</i>	0.05	<i>0.08</i>	-0.05	<i>-0.08</i>	0.67**	<i>0.99</i>
(c) Demographics												
Sex	0.00	<i>0.00</i>	-0.18	<i>-0.27</i>	0.10	<i>0.15</i>	-0.01	<i>-0.01</i>	-0.10	<i>-0.12</i>	0.20	<i>0.24</i>
Age	0.01	<i>-0.01</i>	-0.02	<i>-0.03</i>	-0.09	<i>-0.13</i>	-0.01	<i>-0.01</i>	0.07	<i>0.09</i>	0.07	<i>0.09</i>
(d) EPQ-R Scales												
E	0.02	<i>0.03</i>	0.10	<i>0.17</i>	-0.05	<i>-0.08</i>	-0.19	<i>-0.27</i>	-0.07	<i>-0.10</i>	-0.07	<i>-0.10</i>
N	-0.19	<i>-0.31</i>	0.15	<i>0.26</i>	0.22	<i>0.37</i>	-0.01	<i>-0.01</i>	0.38**	<i>0.55</i>	0.27*	<i>0.38</i>
P	-0.28*	<i>-0.57</i>	0.34**	<i>0.72</i>	-0.05	<i>-0.11</i>	0.05	<i>0.09</i>	0.08	<i>0.14</i>	0.14	<i>0.25</i>
L	0.38**	<i>0.62</i>	-0.17	<i>-0.29</i>	-0.25*	<i>-0.42</i>	-0.03	<i>-0.04</i>	-0.08	<i>-0.11</i>	-0.10	<i>-0.14</i>
(e) EPP Scales												
<i>Extraversion scales</i>												
Act	0.05	<i>0.08</i>	-0.22**	<i>-0.37</i>	0.09	<i>0.15</i>	-0.11	<i>-0.16</i>	-0.17	<i>-0.24</i>	0.24*	<i>0.33</i>
Soc	-0.30**	<i>-0.47</i>	-0.03	<i>-0.05</i>	-0.04	<i>-0.06</i>	0	<i>0.00</i>	0.14	<i>0.19</i>	0.33**	<i>0.45</i>
Ass	-0.13	<i>-0.21</i>	-0.24*	<i>-0.41</i>	-0.13	<i>-0.22</i>	0.02	<i>0.03</i>	-0.10	<i>-0.14</i>	0.56**	<i>0.79</i>
Amb	0.24*	<i>0.38</i>	-0.19	<i>-0.31</i>	0.03	<i>0.05</i>	-0.04	<i>-0.06</i>	0.08	<i>0.11</i>	-0.02	<i>-0.03</i>
Dog	-0.16	<i>-0.30</i>	-0.15	<i>-0.29</i>	0.12	<i>0.23</i>	-0.11	<i>-0.18</i>	0.08	<i>0.13</i>	0.27**	<i>0.44</i>
Exp	-0.14	<i>-0.26</i>	0.18	<i>0.35</i>	0.04	<i>0.08</i>	-0.1	<i>-0.17</i>	-0.01	<i>-0.02</i>	0.29**	<i>0.47</i>
<i>Neuroticism scales</i>												
Inf	0.03	<i>0.05</i>	0.11	<i>0.18</i>	0.12	<i>0.19</i>	0.15	<i>0.20</i>	0.06	<i>0.08</i>	-0.30**	<i>-0.40</i>
Unh	-0.07	<i>-0.11</i>	0.08	<i>0.13</i>	0.21*	<i>0.33</i>	0.17	<i>0.23</i>	-0.12	<i>-0.16</i>	0.11	<i>0.15</i>
Dep	-0.07	<i>-0.12</i>	0.22**	<i>0.39</i>	0.17	<i>0.30</i>	-0.08	<i>-0.12</i>	0.16	<i>0.24</i>	-0.15	<i>-0.22</i>
Hyp	0.06	<i>0.10</i>	0.11	<i>0.19</i>	0.08	<i>0.14</i>	0.04	<i>0.06</i>	0.11	<i>0.16</i>	-0.05	<i>-0.07</i>
Gui	-0.01	<i>-0.02</i>	0.02	<i>0.03</i>	0.06	<i>0.10</i>	0.01	<i>0.01</i>	0.03	<i>0.04</i>	0.05	<i>0.07</i>
Obs	0.22*	<i>0.37</i>	-0.19	<i>-0.33</i>	-0.11	<i>-0.19</i>	0.07	<i>0.10</i>	0.18	<i>0.26</i>	-0.02	<i>-0.03</i>

(continued on next page)

Table 2 (continued)

	Revised GWPQ Scales											
	Imp				Anx				FFS			
	AA	(AA)	AP	(AP)	EX	(EX)	PA	(PA)	FL	(FL)	FI	(FI)
<i>Psychoticism scales</i>												
Ris	-0.33**	-0.57	0.13	0.23	-0.08	-0.14	-0.12	-0.18	-0.25*	-0.38	0.30**	0.44
Irr	-0.35**	-0.59	0.17	0.30	0.16	0.28	0.03	0.04	-0.08	-0.12	0.11	0.16
Man	-0.21*	-0.38	-0.08	-0.15	0.02	0.04	0.01	0.02	-0.11	-0.17	0.43**	0.67
Sen	-0.25*	-0.40	0.00	0.00	-0.06	-0.10	-0.12	-0.17	-0.37**	-0.52	0.31**	0.43
Tou	-0.20*	-0.36	-0.05	-0.09	-0.03	-0.06	-0.10	-0.16	-0.30**	-0.47	0.24*	0.37
Prac	-0.39**	-0.64	-0.01	-0.02	-0.14	-0.24	0.01	0.01	0.29**	0.42	0.08	0.11
<i>L</i>	0.41**	0.66	-0.17	-0.29	-0.07	-0.12	0.16	0.23	0.01	0.01	-0.21*	-0.29
(f) Learning styles												
Act	-0.35**	-0.60	0.21**	0.37	0.08	0.14	0.05	0.07	0.08	0.12	0.21**	0.31
Ref	0.38**	0.61	-0.20*	-0.34	0.10	0.17	-0.05	-0.07	-0.04	-0.06	-0.16*	-0.22
The	0.33**	0.54	-0.30**	-0.51	-0.07	-0.12	-0.09	-0.13	-0.20**	-0.29	0.12	0.17
Prag	0.1	0.17	-0.21**	-0.36	-0.04	-0.07	-0.27**	-0.39	-0.26**	-0.38	0.20**	0.29

Note sample size is either 100 or 170 depending upon which group(s) the questionnaires were administered to. The same abbreviations as Table 1 are used. In addition, Imp = Impulsivity, Anx = Anxiety, FFS = Fight/Flight System, E = Extraversion, N = Neuroticism, P = Psychoticism and L = Lie scale, Act = Activity, Soc = Sociability, Ass = Assertiveness, Amb = Ambition, Dog = Dogmatic, Exp = Expressiveness, Inf = Inferiority, Unh = Unhappy, Dep = Dependence, Hyp = Hypochondria, Gui = Guilt, Obs = Obsessive, Ris = Risk taking, Irr = Irresponsible, Man = Manipulative, Sen = Sensation seeking, Tou = Toughmindedness, Prac = Practical, Act = Activist, Ref = Reflector, The = Theorist, Prag = Pragmatist. Note that the Flight scale is reverse scored compared to Table 1.

* $P < 0.05$.

** $P < 0.001$.

primary scales are predicted by Active avoidance and Fight and/or Flight. Despite the high correlations between the Neuroticism primary scales of the EPP (see Jackson et al., 2000), the correlations of these scales with the revised GWPQ scales are sparsely significant, except for Anxiety. The revised scales do not predict Extraversion of the EPQ-R, but do predict Neuroticism and Psychoticism.

In this study, the revised scales were also correlated with the scales of the LSQ. Interestingly, the Activation scales are correlated with almost all learning styles and the Fight and Flight scales are correlated with some of the scales. None of the inhibition scales are correlated with learning preferences.

4. Discussion

Jackson (2002) determines how well the original GWPQ scales explained the EPP primary scales. He concludes that (a) the primary scales of the EPP are not well explained by the GWPQ and (b) that there is a consistency to the amount of activation and inhibition components

explaining the EPP scales. His study can be criticized in that item overlap of the GWPQ leads to a lack of specificity in its scales, which in turn leads to his study really only looking at general activation and inhibition in the prediction of the surface scales of personality. Results of this study take this process a step further because it seems to have been possible to identify an orthogonal scale structure to the GWPQ. This study finds:

1. Remarkable consistency in that Extraversion primary scales of the EPP are generally and uniquely explainable in terms of the Fight scale. Based on the premise that Gray's RST represent a partial basis for personality and the EPP primary scales represent the surface scales, quite how the animal learning tendency to aggressively fight back might predict extraversion primary scales in such a consistent manner is a puzzle. It seems possible to explain these results such that the Fight scale (and *not* the BAS system) is responsible for the general cortical arousal mechanism outlined by Eysenck (1967) as the cause of Extraversion. Such an explanation would agree with Corr's (2001) belief that Gray's RST may be responsible for general arousal and emotional responses far beyond what a strict interpretation of RST suggests. Nevertheless, what is clear is that such a relationship is not specifically predicted by Gray's RST since it predicts that the role of activation is played by the BAS and not Fight.
2. Further analysis of the items of the GWPQ and EPP suggests that the Fight items must be extremely fight related and be related to defensive and not predatory aggression for the relationship with Extraversion primary scales to be upheld. This reinforces the possibility that the revised Fight scale may represent non-aggressive general arousal. Although, Eysenck (1967, 1997) has no place for the BAS or Fight in his model of the causes of Extraversion, the idea that 'non-predatory aggression' is a cause of Extraversion provides general support for his model from within RST, whilst requiring substantial modification of the links between RST and Extraversion. On this subject, it is important to note that Extraversion of the short form of the EPQ-R is not predicted at all from Gray's RST scales. This is likely to be due to differences in scale operationalization between Extraversion of the EPQ-R (Short) and the extraversion primary scales of the EPP.
3. Psychoticism primary scales of the EPP are consistently explainable in terms of *low* Active-Avoidance and then a mix of Fight and/or Flight. The interpretation here is that high psychotic tendencies are predicted by *not* taking positive steps to avoid punishment as well as fight and low flight characteristics. Gray's RST correctly relates Fight and Flight to the prediction of Psychoticism primary scales, but does not predict the remarkably consistent effect of low Active-Avoidance. This problem for Gray's RST is confirmed in that Psychoticism of the EPQ-R is predicted by Approach and low Active avoidance which again suggests that the BAS predicts Psychoticism.
4. Anxiety of the EPP is predicted by Passive-avoidance, Extinction and Flight. That Extinction and Passive-avoidance predict Anxiety fits in well with Gray's RST. However my results show that Flight is clearly located with Extinction and Passive-avoidance as opposed to forming part of the Fight–Flight system. This is a further important criticism of Gray's system in that Flight does not seem to belong to the FFS.
5. Apart from Anxiety, other neurotic primary scales of the EPP are not explainable by the revised GWPQ scales. This is another somewhat puzzling finding given the high correlations

between the neurotic primary scales of the EPP (see Jackson et al., 2000), but the suggestion here is that Gray's model is an excellent and precise predictor of Anxiety, but that other primary scales of Neuroticism have some other basis to that of Gray's RST.

6. The activation:inhibition balance discussed by Jackson (in press) seems less attractive with the use of very tightly operationalized and orthogonal scales used in this study. The original GWPQ scales seemed to suggest that many of the scales of the EPP could be predicted from a general balance of activation and inhibition mechanisms. The finer analysis presented here suggests that this effect is minimal.
7. The revised GWPQ scales are uncorrelated with sex and age. This is a positive finding for Gray's RST since a biological model is stronger if it is stable over age and sex effects (although it should be noted that a biological model does not have to be stable in terms of sex and age in order for it to be classified as a biological model).
8. Approach, Active-avoidance of the BAS, Fight and to a smaller extent Flight are correlated with learning styles. These results replicate findings that suggest a link between learning and Extraversion and Psychoticism, but little link with Neuroticism (Furnham, 1992; Furnham et al., 2001; Jackson & Lawty-Jones, 1996). Such findings tend to indicate that Gray's RST has a more general use in understanding learning than responses to conditioned stimuli from the BIS and BAS and responses to unconditioned stimuli from the FFS. Corr (2001) seems correct to note that Gray's RST appears to explain general learning extremely well and therefore to suggest that Gray's RST has a wider scope than can be predicted from a strict interpretation of the theory.
9. It is also interesting to note that high Active-avoidance and low Fight are consistent predictors of the Lie scale in the EPQ-R and the EPP. It seems that taking positive steps to avoid punishment, and possibly the low arousal induced by submission (i.e. low Fight) predicts social desirability (or faking good which is a usual way of interpreting high lie scale scores). Whilst this seems to be an intuitively appealing explanation of social desirability, it does contrast with existing theories (see Furnham, 1986).
10. It is possible to get independent scales measuring Gray's RST, which suggests that the systems may not be joint as theorised by Corr (2001). In fact, this study suggests that it is possible to derive functionally independent sub-scales of Gray's RST that have an additive effect.
11. We now know how to create good items to improve the GWPQ. It is clear from item analysis that many of the items of the original GWPQ were loading on more than one scale with the result that the questionnaire was really only able to detect general activation and inhibition (see Jackson, in press). The analysis presented in Table 1 suggests the items comprising the scales need to be extremely carefully designed with very specific content areas. For example, Approach seems to best operationalized in terms of approaching primary needs, and divergence from the focus of primary needs can lead to a correlation with Active-avoidance. In this study, only two Approach items met the criterion of independence from other scales, but now this content area can be developed to generate a more robust scale of Approach.
12. Corr (2001) also emphasises that the BIS system is sensitive to conditioned aversive stimuli, the BAS is sensitive to conditioned appetitive stimuli and the FFS is sensitive to unconditioned aversive stimuli. A revised GWPQ may need to reflect these different types of

conditioning as far as is possible within a questionnaire design. It would also seem useful to develop questions that are sensitive to unconditioned appetitive stimuli.

13. More generally it needs to be noted that correlations between RST scales and surface scales of personality are generally only moderate (although they do improve when corrected for attenuation), and this suggests a robust but relatively minor role for RST in providing a causal basis for personality.

The major limitation of this cross-sectional psychometric research is that it is non-causal. I have a priori reasons for predicting EPP scales from GWPQ scales as Gray's RST model is presented as a causal basis to personality (as implicitly suggested, for example, by Corr, 2001; Gray, 1970, 1982, 1987; Matthews & Gilliland, 1999) and the EPP scales seem to represent the surface scales of personality, but this is not tested for in these results.

Once the GWPQ has been revised to derive scales of much higher reliability and with a larger number of items, it will be possible to look at interactions between the scales to determine if there is a significant multiplicative effect as well as the additive effects reported in this paper. Reliability of an interaction term is a multiple of the reliabilities of the uncorrelated scales within the term and thus would be very low with the present data set. Such interactions would help us understand if separate systems reported in this study also have a joint effect, as well as separate effects, as theorised recently by Corr (2001).

In summary, Gray's RST seems to have a consistent ability to predict the surface scales of personality. It seems that Gray's RST has more general effects than a strict interpretation of RST predicts, but that there are inconsistencies between RST and results of this study.

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