

-RXUQDO RI 2QFRORJ\ 5HVHDFK DQ
7UHDWPHQW

\$KPDG HWDO 5HV 2QFRO 7U

5HVHDFK \$UWLFOH

2SHQ \$F

7KH ,PSOLFDDV3*HQH R\SHUPHWK\ODWLRQ LQ &

6KD\LVWD \$KPDG DU 5DVHGLKD 1L\DHG 1L\DHG 6\HG 0XGDVVDU
'HSDUWPHQWV RI &OLQLFDO %LRFKHPLVWU\ 6KHU , .DVKPLU ,QVWLWXWH RI 0HGLFDO 6FLHQFHV -DPPX D
'HSDUWPHQW RI 0HGLFDO /DERUDWRU\ 7HFQRORJ\ \$PLW\ 8QLYHUVLW\ +DU\DDQ ,QLD
'HSDUWPHQW RI 0HGLFDO 2QFRORJ\ 6KHU , .DVKPLU ,QVWLWXWH RI 0HGLFDO 6FLHQFHV -DPPX DQG .DVH

\$EVWUDFW

%DFNJURXQG :QW SDWKZD\ LV VWLXPDWHG ERWY53 '1\$KKFSHWHQWKL\ODWLRQ
DFWLWLW\ GRZQUHJXODWHV WKH JHQH H[SUHVVLRQ DQG SURPRWHV &5&

2EMHFWLYHV 7KLV VWXG\ DLPV WR DVVHVW WKH 6\53JLRQVFLRPLSHDFDORH DQSHUP

0HWKRGRDRH\UHVHDFK XVHG WZHQW\ EORRG VDP SOHV IURP SDWLHQWV ZL
6KHU , .DVKPLU LQVWLWXWH RI PHGLFDO VFLHQFHV DV ZHOO DV WKLW\ SDW
FDQFHU ZKR XQGHUZHQW VXUJLFDO H[FLVLRQ LQ WKH GHSDUWPHQW RI JHQHUDO
HPSOR\HG WR 5\53VHWK\ODWLRQ DQG WKH UHVXOWV ZHUH FRUHHODWHG ZLWK VHYH
FKDUDFWHULVWLFV

5HVXOWV 2XU UHVXOWV PHRZHG DWLRQ OHYHOV DUH VLJQLILFDORRQ SUHVHQW
VDP SOHV DV FRPSDUHG WR QRUPDO FRXQWHUSDUWV

&RQFOXVLRQQIHU WKDW WKH KWSH53H\$KPDWLRQ LQ FRORUHFWDO RWXPRUV PD\
WKH GHYHORSPHQW RI FDQFHU LQ QRUPDO FRORQ DQG UHFHXP FHOV

.H\ZRUGY53 0HWK\ODWLRQ 0HWK\ODWLRQ 6SHFLILF 3&5 063 &OLQLFRSDWKROR

,QWURGXFWRQ

&RORUHFWDO FDQFHU LV D YHU\ KHWHURJHQHRXV LOOQHVV WKDW LQFOXGHV
YDULHW\ RI WXPRU SKHQRW\SHV ZLWK GLVWLQFW JHQHWLF DQG PRUSKRORJLFD
FKDUDFWHULVWLFV 3URWR RQFRJHQHV '1\$ UHSDLU SDWKZD\ JHQHV DQG
WXPRU VXSSUHVVRU JHQHV DUH DOO PXWDWHG LQ &5& > @ ,W LV FXUUHQWO\ W
PHW!&D00pÀ`€`v p

D\$E`
5\53JLRQVFLRPLSHDFDORH DQSHUP

GHWHFHWHG LQ RI &5&V \$KPDWLRQVRRQRW:QWYH \$3&
SDWKZD\ WDUJHW JHQHV DLHFRORJ\DFWGHSH\ FHDOWHQLQ LQ
OLQH > @ 6HFUHWHG)6\53VHWK\ODWLRQVH3SURWHLYHV
VHFUHWHG JO\FRSURWHLYHGDVWVH3SURWHLYHV 0QMLQH P&D2 @P

&RUHVSRQGLQ\HG WKSDVVDU 'HSDUWPHQWV RI &OL
6KHU , .DVKPLU ,QVWLWXWH RI 0HGLFDO 6FLHQFHV -D
JRZKDU #JPDLO FRP

5HFHLYHGHHFPEHU 0DQXVF1R\$27 (GLWRU DVVLJQH
'HFHPEHU 3UH4& 1R\$27 34 5HYLHZHG
-DQXDU\ 4& 1R \$27 5HYLVHG0DUFK 0DQXVFULSW
1R \$27 5 3XEOLVKH\$SULO '2, DRW

&LWDWLRQ 5\53VHWK\ODWLRQ 1LVWU 0XGDVVDU 67KH
,PSOLFDDV3*HQH\SHUPHWK\ODWLRQVH3SURWHLYHV &DQFHU
5HV 7UHDW

&RSULJKW \$KPDG HWDO 7KDVORSHQ DFFHVVFOH GLVWU
XQGHUWKH WRUPVUHDVIRYPRQSWWULEXWLRLQSHHDMV
XQUHVWLWVWVHG UDEGHLSURGXFWLRQ LQ DQ\ PHGLXP SU
DXWKRU DQG VRXUFH DUH FUHGLWHG

5HV 2QFRO 7UHDW

3DJH RI

DWWDFKLQJ WR)) SURWHLQV 6)53V P D\WL Q\KHU D F\DV K PWK W\KH VPL W\W\WK RI P BGLF
FUHDWH LQDFWLYH FRPSOH[HV ZLWK))V D\RSI D\RP L WR: Q\RU M E V\DDO EQ Q F6)U 3G/L B D Q R V H
EHHQ VKRZQ WR SRVVLEO\ EORFN WKH LFRP SOW W\H F D B R I D B B : QML W\W\K ZBI W\KH
FRORQ FDQFHU FHOV HYHQ LQ WKH S EIKH P\W K HRJDSX W\DUW U D G V R\K K\WU D S F W L S P R X B
RU FDWHQLQ GRZQVWUHP RI WKH Z H U W H L F P S V G R I D W H O @ I L D K H G 1 \$ L W K V X U J L F
K\SHUPHWK\ O D W L R Z K L R K LV VLWXDWH G R X S P D W U W D F V R H W K B W Z D V Q H D U E \ D Q G
FDQRQLFDO :QW VLJQDOLQJ SDWKZD\ P D X M M Q R K M E Q W R G D W K Z ' D \$ W L D C E H S X U S O
DFWLYDWHG GRZQUHJXODWH JHQH H [S B E O V I E R V H G E I U R P N W I K I Q B 5 I & Q S D W L R H Q Q D Q B O I
SURPRWH &5& \$GGLWLRQDOO\ WKHVH F R I Q O N W H S K I N S R I P K H H I O V D B W L R G L P D G X D O V
VHUYH DV D ELRPDUNHU IRU WKH G H W Z H F W H L R O W R U H S 5 D W @ & O R L O W K L X U W W H G \ S U
LQWHQGV WR HYDOXDWH WKH SURJQRV R L W K H J O P I D F D B G H V R U V K \ S H W P Z H W K H O D M L X L Q
6)53LQ FRORUHFWDQ FDQFHU SDWKRORJ\ 6.,06

0DWHULDOV DQG 0HWKRGV

6DPSOH FROOHFWLRQ

7KH VWXG\ ZDV JLYHQ HWKLFDO FOHDU D Q F H E W W K H H W K L F D O F O H D U D Q F H E W W K H H W K L F D O F R P P L W W H B R I
6.,06 6ULQDJDU -DPPX DQG .DVKPLU P H W K I O D W L R Q D O G X Q D P H W K O P W H G I D O O H
ZULWWHQ FRQVHQW 7KLUW\ KLVWRORJL F D O O F R Q L U P H G F R O B U H F W D O E D V H S
SHRSOH Z\K R J L F D O H [F L V L R Q L Q W K H G S D U W P H Q W R I J H Q H U D O V X U J H U \ E D V H S

&S* VWDWXV 3ULPHUV ¶ ¶ \$QQHDOLQJ WHP SHUDWXUR XFW VLJH ES
6)53 0) ***7&***\$77777&***\$77* & *P0P0*P0EiÜ gFe\$Dl)*7`z**\$*\$*\$7*
ZHUH XVHG IRU GLVFUHWYDULDEOHV 3HDUVRQ V \$ WHVW

5XUDO	
8UEDQ	
6RFLDO FODVV	
/RZ	
0LGGOH	
)DPLO\ KLVWRU\	
<HV	
1R	
6PRNLQJ VWDWXV	
6PRNHU	
1RQ VPRNHU	
/LIHVW\OH	
\$FWLYH	
6HGHQWDU\	
%RG\ PDVV	
1RUPDO	
2EHVH	

8QGHUZHLLJKW

6DOW WHD LQWDNH

<HV

1R

5HG PHDW FRQVXPSWLRQ

<HV

1R

6XQGULHG YHJHWDEOHV

<HV

1R

-XQN IRRG FRQVXPSWLRQ

<HV

1R

3HVWLFLGH H[SRVXUH

<HV

1R

6LWH RI WXPXU

&RORQ

5HFWXP

7XPRXU GLIIHUHQWLDWLRQ

&KDUDFWHULVW	LPHWK\ODWLRQ	SUHVHQW	0HWK\ODWLRQ	DEVH	Q3WYDOX	HGGV	UDW	&RL
\$JH								
!								
"								
*HQQGHU								

0DOH

)HPDOH

'ZHOOLQJ

5XUDO

8UEDQ

6RFLDO FODVV

/RZ

0LGGOH

)DPLO\ KLVWRU\

<HV

1R

6PRNLQJ VWDWXV

6PRNHU

1RQ VPRNHU

/LIHVW\OH

\$FWLYH

6HGHQWDU\

%RG\ PDVV

1RUPDO

2EHVH

8QGHUZHLJKW

5HG PHDW FRQVXPSWLRQ

<HV

1R

6XQGULHG YHJHWDEOHV

<HV

1R

-XQN IRRG FRQVXPSWLRQ

<HV

1R

3HVWLFLGH H[SRVXUH

<HV

1R

6LWH RI WXPRU

&RORQ

5HFWXP

7XPRU GLIIHUHQWLDWLRQ

:HOO

0RGHUDWH

3RRU

710 VWDJH

7

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sIFt' d4y3D À ÁP •

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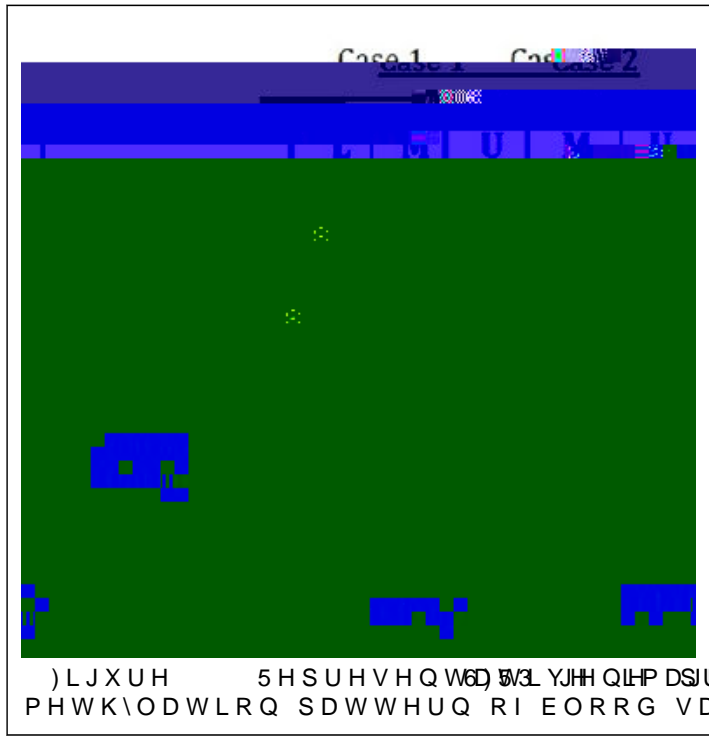
7 7

6WDJH

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/ ES XQPHWK\ODWHG 6)53 LV L@GLFD
ES ZKLOH6D53YJH QIHP DSUHR FRR WHU
,Q EORRG6)53YJH QIHP SURPRWHU PHWK\ODW
DVVHVVG LQ &5& FDVHV DQG DOVR
EUHVHQWÂ900

)LJXUH 5HSUHVHQW6D53 YJH QIHP DSUHR FRR WHU
PHWK\ODWLRQ SDWWHUQ RI EORRG VDP SOHV RI VXEMHFWV E\ 063

\$FWLYH	
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6HGHQWDU\

%RG\ PDVV

1RUPDO

2EHVH

8QGHUZHLLJKW

6DOW WHD LQWDNH

<HV

1R

5HG PHDW FRQVXPSWLRQ

<HV

1R

6XQGULHG YHJHWDEOHV

<HV

1R

-XQN IRRG FRQVXPSWLRQ

<HV

1R

3HVWLFLGH H[SRVXUH

<HV

1R

6LWH RI WXPRXU

&RORQ

5HFWXP

7XPRXU GLIIHUHQWLDWLRQ

:HOO

0RGHUDWH

3RRU

710 VWDJH

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7 7

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6WDJH

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7XPRXU JUDGH					

,Q &5& WXPRU VDP SOHV WKHUH ZDV QR GLVFHUQLEOH UHODWLRQVKLS
EHWZHHW JHQH SURPRWHU K\SHUPHWK\ODWLRQ DQG DQ\
FOLQLFRSDWKRORJLFDO IDFWRU VXFK DV DJH WXPRU GLIIHUHQWLDWLRQ RU VW
+RZHYHU WKH VWXG\ VDP SOH VLJH ZDV H[WUHPHO\ WLQ\ ZKLFK PLJKW
DFFRXQW IRU WKH ODFN RI VWDWLVWLFDO VLJQLILFDQFH

1R VLJQLILFDQW VWXG\ LQ WKH SDVW KDV FRUHHODWHG K\SHUPHWK\ODWLRQ R
WJH JHQH ZLWK FOLQLFRSDWKRORJLFDO FKDUFWHULVWLFV ZKHUHDV /L HW
DO FRUHHODWHG WKH H[SUHVVLRQ RI WKH JHQHQP 0JHQH ZLWK FHIUDW
FOLQLFRSDWKRORJLFDO)Rfp`°@P@`p€PÀ`pÀ`2'gx DQG)Rfp•(@ p2'gx G)Rfs VWDWLVWLFDH
FRVRLRD VLIHQ ZLWK VLIHQDWHG /V Dp'€U%L WJH LFLFDQFH Cw€•0 JHQ•@QP 0JHQH Cw€°À0€